Supplemental

Technical Support Document for Federal Implementation Plan

Response to Comments Summary of Rule Changes

Architectural Coatings

February 13, 1995

Architectural Coatings

Disclaimer: The mention of any trade names, manufacturers, or commercial products does not constitute endorsement or recommendation for use.

Summary of proposal: As described in the NPRM at 59 FR 23317, EPA proposed that architectural coatings supplied, sold, offered for sale, applied, solicited for use, or manufactured meet specified VOC content limits. The proposed limits built on existing architectural coatings regulations and would phase in lower VOC limits in 1996, 2000, and 2003.

Summary of changes from proposal:

Compliance date changes: all categories

Revised from January 1, 1996 to May 15, 1997. Revised from January 1, 2003 to January 1, 2004

New definitions and limits:

Chalkboard Resurfacers (450 g/l, 420 g/l) Flow Coatings (650 g/l, 420g/l) Grams of VOC per liter -- Low solids Heat Reactive Coatings (420 g/l) Quick-Dry Enamels (400 g/l, 250 g/l)

Revised definitions:

Below-ground wood preservatives
Impact immersion coatings
Low-solids stain or wood preservative
Nuclear power plant coatings
Opaque wood preservatives

Semi-transparent wood preservatives

Revised limits or effective dates:

Antenna Coating	2000 @ 340 g/l deleted
Anti-Fouling Coating	2000 @ 340 g/l to 2004 @ 350 g/l
Flats	2000 @ 150 g/l to 200 g/l
Flats	2003 @ 50 g/l to 2004 @ 150 g/l
Impact Immersion	2000 @ 340 g/l to 2004
Industrial Maintenance, NOS	1996 @ 340 g/l to 1997 @ 350 g/l
Magnesite Cement	2000 @ 500 g/l to 2004
Nuclear Power Plant Coatings	2000 @ 340 g/l deleted
Pretreatment Wash Primers	2000 @ 420 g/l deleted
Primers, Sealers and	
Undercoaters	Sealers deleted
	2003 @ 150 g/l to 2004 @ 275 g/l
Sealers, NOS	2003 @ 150 g/l deleted
Opaque Stains and Wood	
Preservatives	1996 @ 250 g/l to 1997 @ 350 g/l
	2000 @ 200 g/l deleted
Traffic Paints	2003 @ 50 g/l to 2004 @ 100 g/l

New test methods added:

ASTM D 1640-89 SCAQMD Method 311-91 ASTM Method D 1613-85 ASTM D 523

Revised Reduction Estimate:

Reduction estimates have been revised to account for revisions to the categories and limits, changes to the emissions inventory, and a 20 percent rule effectiveness discount. Reductions have also been revised to account for new information contained in "Survey of Emissions from Solvent Use, Volume II: Architectural Coatings, Final Report," (CARB, September 1994). A more

detailed comparison is provided in Appendix A.

Reduction estimates for the three FIP areas are now: 3.4 tpd instead of 3.5 tpd for Sacramento, 1.1 tpd instead of 1.7 tpd for Ventura, and 16.6 tpd instead of 26.0 tpd for the South Coast. Statewide reductions are estimated to be 61.6 tpd. The estimated reductions from the FIP rule may be conservative because they assume that coatings will be reformulated to the lower limit. However, often times, the actual VOC will be less than the limit in the rule. In addition, there are two recognized methods, constant solids and constant gallons, for calculating the emission reductions. The constant solids method will result in a greater reduction when compared to the constant gallons method. Because of the different resin systems used for architectural coatings and the likelihood that one resin system can replace another, neither method best estimates the reductions. Therefore, for purposes of the FIP, EPA used a midpoint estimate which took into consideration both methods.

Revised Cost Estimate:

Cost estimates range from a savings to approximately \$12,000 per ton of VOC reduced. These remain unchanged from the estimate used in the proposal. No new cost per ton estimates were provided by the commenters.

Major Comments Received:

General

Comment: The EPA should delete this measure from the FIP.

Response: The architectural coatings FIP measure is necessary to reduce VOC emissions in all three FIP areas. In each area, the districts and State support an attainment strategy which includes VOC and NOx reductions. Because architectural coatings comprise a sufficient portion of the inventory in each FIP area, EPA believes that additional VOC reductions are needed for attainment.

Relationship to the Regulatory Negotiation

Comment: The FIP proposal is inconsistent with the Reg Neg proposal

Response: The FIP was proposed in February 1994 prior to an EPA proposal to the Reg Neg committee. EPA Region IX has reviewed EPA's (OAQPS') recent Reg Neg proposal and added new definitions and categories to the FIP rule. These new definitions and limits are largely an outgrowth of the Reg Neg and do not represent a strengthening of the FIP proposal; therefore, EPA has revised the FIP accordingly. Please review the redlined version of the rule in the TSD to view most of the changes from the proposal. Some of the limits and definitions in the EPA proposal for the Reg Neg Committee were not appropriate for inclusion in the FIP rule because the limits were already more stringent in the State Implementation Plan architectural coatings rules. EPA will review the appropriateness of the FIP rule when the national rulemaking is completed. Because of the court-ordered deadlines EPA must finalize the FIP by February 14, 1995, well in advance of the national program.

Comment: The FIPs undermine the Reg Neg process.

Response: The FIP is not intended to undermine the Reg Neg process. It is not clear how the FIP would undermine the Reg Neg process, since the Reg Neg Committee has disbanded because consensus could not be reached. EPA is not aware that the FIP had any direct impact on the Reg Neg since it could have been but was not openly discussed at the Reg Neg.

Comment: EPA should revise FIP to be same as national rule.

Response: Upon completion of the national rulemaking, EPA will review the FIP rule for potential changes. EPA has revised the proposed FIP measure for greater consistency with the proposal presented to the Reg Neg Committee in July 1994. EPA does not consider these changes to be a strengthening of the proposal therefore the changes do not require a reproposal.

Comment: Commenters support a national rule in place of the FIP.

Response: Many commenters expressed preference for a national rule. Until

such time as EPA completes work on meeting the 183(e) provisions of the Clean Air Act, it is speculative on whether there will be a national rule. When completed, EPA will review the 183(e) outcome to determine its potential impact on the FIP measure. In addition, the last proposal presented by EPA to the Reg Neg Committee contained numerous coating limits which would relax limits in current SIP rules. EPA believes that it is not appropriate to relax current SIP or proposed FIP standards just because those higher limits were included in the Reg Neg proposal.

VOC Controls Are Misdirected

Comment: Ambient monitoring needs to be reconciled with the emission inventory.

Response: As mentioned below, the ambient monitoring and inventories are constantly being updated and improved. This is especially true for the mobile source emissions. These issues could be studied for many years; however, EPA believes that enough information is available which indicates that additional VOC reductions are needed for attainment of the ozone standard.

Ambient monitoring for ozone is currently part of air quality programs. This monitoring is intended to measure primary pollutants of concern (e.g., ozone) and allows the regulators to directly measure air quality improvements. Ozone is formed by the chemical interaction of NOx, VOCs, and sunlight. The emission inventory represents a categorization of the numerous sources of pollution which contribute to ozone formation. The monitoring and emission inventory data are reconciled through the modeling process. The information used is the best available. The monitoring, emission inventory, and modeling processes are continuously undergoing improvement and refinement. EPA believes that this process adequately reconciles the ambient monitoring with the inventory.

The VOC emission inventory development process is discussed below. Ambient monitoring for VOC may better reflect emission inventory data after refinements to the mobile source model are made.

Comment: Mobile source VOC emissions are underestimated.

Response: EPA based its mobile source estimates used in the proposed FIP on information supplied by CARB which was then run through EPA's mobile source model. The final FIP was based largely on more up-to-date information from CARB provided in their November 1994 SIP submittal. Although improvements to mobile source inventory estimates are ongoing, the mobile source inventories used in the FIP reflect the best and latest estimates available. As new mobile source estimates become available, EPA along with the state and districts will consider adjustments to the ozone attainment strategies as necessary.

Comment: Biogenics were not adequately accounted for.

Response: The modeling used for the FIP (and SIP) included consideration of the biogenic emissions. The impact of biogenics is unique to each nonattainment area. For example, in the South Coast Air Basin, the minimal biogenic impacts which do occur are predominantly downwind and have minimal impact on ozone concentrations. Biogenic emissions are accounted for in the Urban Airshed Model used to evaluate NOx and VOC reduction strategies needed for attainment; this is further discussed in Section III.G.3 of the Federal Register.

Comment: Ozone levels correlate directly to NOx.

Response: EPA based its VOC:NOx reduction ratios in the FIP on information supplied by the State and districts. The ratios used in the final FIP are based on those provided in the recently submitted SIPs. In each case the ratios include NOx and VOC reductions and are based on recent modeling. While there may be some nonattainment areas in the United States that can achieve attainment through only NOx reductions, the districts and the State have recommended to EPA and included in their SIPs a combination of NOx and VOC reductions as the preferred methods to attain the ozone standard.

Comment: EPA has ignored National Academy of Sciences Report

Response: The NAS report emphasized the need for serious consideration of the impact of NOx in ozone formation and attainment strategies. EPA believes the FIPs more than adequately take into consideration the NAS In each of the areas, EPA has determined, with the recommendation. assistance of the State and local districts, that both NOx and VOC reductions are necessary to attain the ozone standard. The VOC:NOx ratios used in the FIP were based on information from the State and districts. Many California nonattainment areas (e.g. South Coast AQMD and Ventura APCD) have been addressing the importance of NOx reductions for years and have undertaken numerous measures (i.e., NOx RECLAIM) to achieve NOx reductions. In fact, the South Coast has been adopting NOx reduction measures since the 1970s. The recent South Coast 1989, 1991, and 1994 Air Quality Management Plans indicated the need for NOx reductions for ozone attainment. However, each attainment strategy which includes NOx reductions also includes VOC reductions.

VOC Limits Are Counterproductive

Comment: Architectural coatings are a small percent (i.e., less than one percent) of problem.

Response: Collectively architectural coatings are one of the largest groups of stationary and area source VOC emissions. South Coast Air Basin's projected 2010 inventory estimates (which include credit for previously adopted rules) indicate that architectural coatings will account for over 7% of the total VOC 2010 inventory. Ventura and Sacramento estimates range from 7-10% of their VOC inventories. This represents a relative increase in the percent of total emissions from 1990 emissions when compared to other VOC categories after credit for already adopted rules. In other words, architectural coatings will comprise a larger percentage of attainment year emissions when compared to 1990 levels.

Given that additional VOC reductions are necessary, that architectural coatings account for a significant portion of the projected attainment year inventories, and the progress in low-VOC technologies, EPA believes that additional reductions can be achieved from the architectural coatings category.

Comment: Reformulation of coatings to an optimum VOC level is acceptable but substitution or banning of coatings is not acceptable.

Response: EPA believes that available lower VOC resin systems can adequately meet the performance needs of the users. In addition, the low VOC technologies have steadily improved with time. The rule allows additional time for continued improvement of existing technology prior to the effective date for some categories. EPA acknowledges that some higher VOC resin systems can only be reformulated to a defined limit after which may become less effective.

As is the case for any higher polluting product, whether it be an automobile engine or consumer product, lower limits may result in some products being removed from the market. In many cases this is needed in order to facilitate the desired change. The central question is whether or not there are low VOC products which can perform adequately to replace the higher VOC resin systems. For example, quick dry alkyd coatings are being phased out by the FIP rule. Is this a ban or good policy? EPA does not believe that it is appropriate to protect certain resin systems if other systems can adequately meet the customer needs. Quick drying acrylic water borne coatings are perceived by EPA to perform adequately to meet the needs of users. In addition water reducible urethane enamels, water reducible epoxies, and high-solids, alkyds are available. Tremendous progress has been made and continues to be made in the area of waterborne technology. EPA believes that the continued need for high VOC resin systems has not been adequately demonstrated by the commenters.

EPA is open to exploring other mechanisms (e.g., emissions fees) which will allow the continued sale of high VOC resin systems yet achieve equivalent reductions. However, an agreed upon mechanism could not be developed in time to meet the court ordered deadline. Indeed, very few commenters expressed an interest in any of the potential market incentives discussed in the FIP proposal.

Comment: Lowering the VOC content may be counterproductive because "less adequate alternative products" can result in more coating applied, more thinners needed, and more frequent recoating. The end result may be more emissions instead of an emissions reduction.

Response: EPA takes this comment very seriously. Increasing emissions is not the intention of the FIP or this measure. The commenter does not argue that in fact increased emissions will occur only that they "can" occur. EPA believes the comment is a red herring. This argument, that lower VOC coatings increase emissions, is theoretical, unfounded, and lacks compelling evidence.

On the contrary, there are numerous examples of low VOC systems which perform better than the traditional higher VOC systems and which result in less emissions. For example, exterior waterbased acrylics are widely recognized as superior to higher VOC alkyds when applied to the exterior of homes. As some of the articles included in this TSD describes, low-VOC coatings are available today and continue to improve in their performance.

Regulators have repeatedly asked these same commenters for documentation, test results, or factual evidence which supports their claims and indicates the extent of the perceived problem. What has been received is anecdotal evidence. Instead these assertions appear to be an attempt by certain manufacturers to preserve certain product lines. Because the commenters did not specify which coatings their statements apply to, it is literally impossible to refute such an accusation.

Comment: The use of lower VOC coatings can result in more material being applied on each job.

Response: It is not clear exactly what the commenters were referring to since no specifics were provided. However, for purposes of this response, EPA will assume the commenter means that the lower VOC coatings result in a thicker film (i.e., more coating per ft²) or need for more primers, sealers, and undercoaters. Again, the commenters did not provide any specifics regarding which coating type their accusation applies to, the frequency of where this could occur, or under what situation it could occur.

EPA reviewed recommended coverage rates for low-VOC coatings and compared them with higher VOC coatings. For the majority of coatings reviewed, manufacturers recommended coverage rates per gallon which were similar regardless of whether the coating was high or low VOC. This is

highlighted in the example below for semi-gloss and gloss interior trim coatings:

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Туре	VOC	Recommended Coverage/Gallon	Recommended Dry Film	Company
alkyd, low-VOC	250	400	2.0	Sherwin Williams
	250 250	400-450 400-500	1.5-1.7 1.5	PPG Benjamin Moore
latex, low-VOC	181	300-400	na	Devoe
	<250	400-450	1.04-1.34	Valspar
	<250 81	400-500 300-350	1.2 na	Benjamin Moore AFM
	<250	400-450	0.8-1.0	PPG
alkyd, quick-dry	400	300-450	2.0	Sinclair
Su .	443	321-428	1.5	Devoe

The higher solids, low VOC coatings are recommended with similar coverage rates as the higher VOC coatings. The higher solids coating is typically more viscous, but users can adjust their application technique to overcome this issue. The higher solids, low VOC alkyds tend to experience more yellowing than higher VOC alkyds. It is important to note that thinning will not overcome yellowing. Yellowing will intensify where the coating is applied to a surface which experiences little sunlight.

An attached paper, "High-Solids Coatings For Steel Close the Performance Gap" (Modern Paint and Coatings, February 1992), demonstrates that higher solids, lower VOC coatings result in less VOC emissions when compared to traditional coatings. In this case, it is also important to note that the lower VOC product performed equivalent or better than the conventional higher VOC coating. In another attached paper, "High-Build Aliphatic Polyurethane Topcoats" (Modern Paint and Coatings, February 1994) the authors demonstrate that a lower VOC, high build two-coat coating system results in fewer coats when compared to the conventional three-coat system. Not only was the coating performance comparable but also it had a lower cost per square foot when compared to a conventional system.

EPA reviewed manufacturer's recommended finishing systems to determine if more primers, sealers, or undercoaters were recommended for low-VOC coating systems. For the majority of coatings reviewed, manufacturers recommended similar amounts of primer and finish regardless of the VOC of the coating. There was no specific recommendation which indicated that users should apply more primers, sealers, undercoaters when a low-VOC finish (i.e., latex or high solids) was involved. When painting an unfinished surface, a primer is recommended regardless of whether the finish coat is low VOC or high VOC. It is important to note that on unfinished surfaces many contractors are using waterborne primers. In addition, use of waterborne primers can typically result in two-to-three times less VOC emissions when compared to a 350 g/l solventborne primer.

The issue of potential increased use of coatings resulting from the use of lower VOC products has also been reviewed by the CA Technical Review Group, CARB, South Coast AQMD, and Ventura APCD. CARBs responses to these claims were included in the original TSD prepared for the FIP proposal. See attached paper prepared by Ventura APCD, "Ventura County Air Pollution Control District Response to Southern California Paint Manufacturer's Association Regarding VCAPCD Rule 74.2." Each of these agencies or groups have arrived at the same conclusion that there is no substantive evidence that use of low-VOC coatings will result in more coatings used and more emissions when compared to the higher VOC systems. EPA believes that there is no substantive evidence that the lower VOC products are resulting in more emissions. In fact, the evidence indicates the contrary, that many low VOC products provide adequate or superior performance.

In an informal survey of Bay Area painting contractors, EPA confirmed that the waterbased systems are performing extremely well under the majority of circumstances and are being used for the majority of coating applications. For exterior residential applications, waterborne systems are almost exclusively used. For residential interior applications, some higher VOC coatings are used for certain applications. Contractors indicated that quick-dry (QD) alkyds were being used for some interior trim and doorways.

The quality and performance of the high solids, low VOC coatings have continued to improve over time. For users who are not satisfied with the performance of the high solids, low VOC solventborne coatings, other

alternatives are available, such as waterborne acrylics, urethanes, epoxies or the QD enamel coating. The FIP will allow the continued use of the QD alkyds until January 2000. After that, a small container exemption will remain in effect until 2004. Thus the FIP allows the continued use of QD enamels for a limited time.

Given the interim allowance for the continued use of QD enamels, the additional time provided for the transition to compliant systems, and the continued improvement and development of the low VOC systems, EPA believes that the FIP adequately addresses the needs and concerns of the users. Based on changes to the rule and the discussions above, EPA believes that the proposed changes will result in a substantial decrease in emission reductions.

Comment: The lower VOC limits can result in more thinners being added to the coatings.

Response: The commenters have not provided any evidence that thinning is occurring, specified where the thinning might occur, what coatings are being thinned, or under what circumstances thinning might be desirable.

It is important to make clear that if coatings are being thinned with VOC emitting solvents, thinning would only be an option for a limited number of coatings. Waterbased coatings, which account for 75 percent of the gallons sold in California, are thinned with water. Epoxies are formulated to an exact multi-component mixture; if solvents were added, the coating may not even perform. Users who thin beyond the manufacturer's recommendations also risk voiding any warranties provided by the manufacturer. EPA estimates that the coatings most likely to be thinned (e.g., the higher solids coatings) account for less than one percent of the coatings sold in California. EPA believes that if some of these coatings are being thinned, they would account for a very small percentage of the coatings in use and the resulting emissions would be insignificant compared to the reductions achieved by the rule.

CARB conducted a study of the thinning issue in 1991. The study, "Field Investigation on Thinning Practices During the Application of Architectural Coatings in Selected Districts in California" indicates that only 6% of the observed coatings were thinned beyond the allowable limit.

In another informal study, the South Coast Air Quality Management District contracted Woodward-Clyde Consultants to investigate the VOC content of solventborne coatings used by painting contractors. The consultants collected, in the field, approximately 32 coating samples. The samples were collected from the paint can just before the paint was applied. By collecting the samples in this manner, any thinning by the contractor prior to application was included in the analysis. Of the samples collected, 21 of the containers listed the VOC content on the label. Analysis of the VOC content indicated that only three of these 21 samples had a VOC content statistically (i.e., greater than 10 percent) above the maximum recommended VOC. The three higher VOC than expected samples indicate that a small percentage of the coatings may have been thinned beyond the manufacturer's recommendation. However, more importantly, the results indicate that 18 of 21 samples had a measured VOC content below or statistically within the manufacturer's recommendations.

A possible candidate for thinning could be the high solids, solvent based alkyds (at 250 g/l). EPA estimates that the 1990 sales of higher solids, non-flat alkyd coatings (i.e., VOC content of less than 350 g/l) approached 775,000 gallons (or approximately one percent of coatings sold in California). If we assume that half of these higher solids, lower VOC coatings were thinned to 400 g/l (the current limit for quick-dry coatings), the additional emissions would be approximately 1.0 tpd for the entire state of CA! This example indicates that the reductions anticipated from the FIP measure, estimated to be over 60 tpd statewide, more than account for the theoretical increased emissions using the generous assumption that half of the 1990 higher solids, nonflat alkyds were illegally thinned. Does thinning result in more emissions? Yes. How extensive is this problem? Based on the evidence, it is an aberration resulting from the transition from traditional higher VOC coatings to lower VOC coatings. EPA believes that although some small amount of thinning may still be occurring, because the candidate coatings are limited, the amount is not having a significant impact on emissions.

The example provided above does not take into consideration that the use of solventborne coatings is decreasing because of the continually improving performance of low-VOC coatings. EPA believes that as lower VOC products (i.e., waterborne coatings) continue to gain increased market share, any incidental thinning which is occurring will continue to decline.

EPA has long recommended that districts and states discount the emission reduction credit for expected reductions if they anticipate that some percentage of sources may circumvent the requirements of the rule. EPA generally recommends that 80 percent rule effectiveness be assumed in the absence of better information. In this circumstance, EPA has applied the 80 percent rule effectiveness to the FIP rule to account for circumvention (e.g., excess thinning). It is also important to note that thinning beyond the allowable limits of a limit in the rule is illegal.

Based on these discussions and the analyses described above, EPA believes that there is little thinning being done beyond what is allowed in the current SIP rules.

Comment: The lower VOC limits can result in more frequent recoating.

Response: The commenters here imply that lower VOC coatings will fail frequently than higher VOC coatings. Again, no evidence is presented which demonstrates that the comment has merit. The warranties provided by paint manufacturers themselves belie the commenter's claims that compliant paints are less durable than high-VOC paints. Many compliant coatings carry a 10, 15, or even 20 year warranty. Many waterborne systems have superior performance when compared to higher VOC systems. For exterior applications, this includes outstanding gloss retention, good color retention, and better resistance to dirt and mildew. For interior applications, the latest generation of waterbornes offer improved flow, leveling, and film build. The new latexes also have better block resistance and washability. These and other improvements are highlighted in the article "New Generation of Latex Gloss Enamels: How Good Are They?" (American Painting Contractor, February 1994). Other recent articles demonstrating the improved performance of low VOC systems include "Water-Borne Technologies for Wood Floor Finishes" (Modern Paints and Coatings, March 1993), "Historic Lighthouse Showcases Water-Borne Maintenance Paint" (Modern Paints and Coatings, June 1989), "Environmental Exposure Testing of Low VOC Coatings for Steel Bridges" (Journal of Protective Coatings & Linings, January 1994). Each of these sample articles, demonstrate that low VOC coating systems meet or exceed the performance levels of higher VOC systems.

EPA believes that the commenters remarks may be referring to obsolete products which have already been replaced in the market. When and if a paint fails, there are a multitude of reasons some of which have little to do with the VOC content, including choosing the wrong coating for the job, insufficient surface preparation, or applying the coating during unfavorable environmental conditions (e.g., high humidity or low air temperature). In addition, paints are offered in varying grades of quality. Users are better off selecting higher end products when performance is especially critical. To the extent that there may still be some quality problems with certain of the lower VOC coatings, there is every reason to believe that such problems will continue to decrease rapidly as better resins and better technological allow continued improvements in the coatings. Recent articles, such as "Very low VOCs, lacquer-type performance" (American Paints & Coatings Journal, May 9, 1994), indicate the continuing improvements in low VOC technology. Again, EPA believes that the widespread acceptance and continued improvement of low VOC coatings indicates that these coatings do not fail more often than the higher VOC counterparts.

Comment: The lower VOC limits can result in solvents used in substitute coatings which frequently can be more reactive or more toxic.

Response: EPA agrees that on a pure reactivity scale, it is possible that some of the VOCs used in low-VOC coatings may react faster than the VOCs in more traditional higher VOC coatings. However, this fact alone does not translate into more ozone formation. EPA believes that there are many more factors that need to be considered. Higher VOC coatings also contain solvents which are very reactive in terms of ozone forming potential. The reactivity of a VOC will be affected by the mix of other pollutants in the air, which is typically unique to each nonattainment area. VOCs tend to build up in the ambient air, especially during air pollution episodes where stagnant conditions trap pollutants within the immediate area. If a VOC does not react immediately, it may eventually react in the same area or downwind, depending on meteorology, temperature, and other factors. Thus the ozone formation is merely delayed or occurs downwind. In addition, the lower VOC coatings reduce the amount of VOCs emitted into the ambient area. So although some VOCs may be more reactive there are fewer VOCs available for ozone formation. As new strategies develop which better address the reactivity of

individual compounds, EPA will consider revising the FIP rule as appropriate. EPA believes the current strategy in the FIP is sound and consistent with the goal of reducing emissions of *all* VOCs considered to be photochemically reactive.

EPA is concerned with the comment that lower VOC coatings contain solvents which are more toxic. Obviously, increasing emissions of toxic air pollutants is not the goal of the EPA. However, the commenters did not provide any studies or documentation which demonstrate that worker or user exposure to toxic compounds will increase. On the contrary, EPA believes that the lower VOC coatings will result in workers and users being exposed to a reduced amount of EPA does not argue the fact that a lower VOC coating may toxic emissions. contain potentially toxic air pollutants; however, EPA strongly believes that users and workers will be exposed to significantly less emissions because there will be fewer VOCs overall in coatings. Higher VOC coatings may also contain toxic air contaminants, but because these coatings contain more solvents, workers and users are exposed to potentially greater amount of toxic emissions. The FIP rule does not mandate which solvents are used in a coating; it is up to the manufacturer to decide which solvents go into the coatings which they choose to market.

Comment: California courts set aside previous revisions to district architectural coating rules based on CEQA

Response: EPA does not believe that the previous court decisions relating to CEQA are justification for not including architectural coatings in the FIP. The courts set aside the district rules because the courts ruled that districts had failed to adequately follow the administrative procedures in California state law (i.e., CEQA). This decision was not an indictment against low VOC coatings or a judgement on the quality or performance of low VOC coatings. In their decisions, the courts did not address the quality or performance issues affecting lower VOC coatings. The three separate court decisions affecting the Bay Area, South Coast, and Ventura district rules should not be taken out of context as justification for not moving forward with architectural coating regulations which lower the VOC content of coatings.

In the cases of the Bay Area and Ventura, the districts claimed that their action

was exempt from CEQA. Based on issues raised by industry, the court concluded that the districts should have performed the additional analysis required under CEQA and that an exemption was not appropriate. The courts did not address the quality or performance of coatings.

In the South Coast, the District determined that the revision to 1113 would have no significant environmental impacts. The courts determined that only with respect to the thinning issue had the district inadequately addressed the potential environmental impacts required by CEQA. The courts ruled in favor of the district on all other issues raised by industry. An Appeals Court agreed with the lower court's decision.

Comment: The FIP is subject to CEQA

Response: EPA believes that the FIP is not subject to the requirements of

CEQA.

Comments on specific coating categories/limits

Comment: Current SIP limits are infeasible and coatings which meet the current limits can not meet performance requirements. Higher limits are recommended for the waterproofing sealers, semi-transparent stains, and varnishes.

Response: EPA believes that the commenter has not acknowledged the large amount of compliant products which are already being sold in California. With respect to performance requirements, the rules do not include performance requirements (since this is a very contentious issue which even industry can not agree on exact performance criteria which could be put into a regulation). EPA believes that because there is not an agreement on which performance requirements to include in the rule, performance is best left for the marketplace to decide. Each of the categories mentioned by the commenter is addressed below.

Comment: Limits should be revised for waterproof sealers from 400 g/l to 600

g/l and for semi-transparent stains from 350 g/l to 550 g/l.

Response: EPA does not concur with this recommendation. Although the manufacturer admitted experiencing problems with their lower VOC products, the manufacturer did not provide compelling technical data comparing available low VOC coatings with their higher VOC coatings. The manufacturer claimed that the products which comply with the current CA SIP limits are not feasible; however, the manufacturer currently markets numerous compliant products in CA and their product advertising appears to contradict their FIP comments. In addition, the manufacturer failed to acknowledge the abundance of compliant products, albeit competitors (e.g., stains: Duckback Products Inc., PPG Architectural Finishes Inc., Behr Process Corp. and waterproof sealers: Behr Process Corp., and PPG Architectural Finishes Inc.) in the market which meet current SIP standards. The FIP measure would maintain the current SIP limit for waterproofing sealers and semi-transparent stains and not require further reductions at this time.

Comment: The varnish limit should be revised from 350 g/l to 450 g/l.

Response: The FIP limit for varnishes would be lowered from its current SIP limit of 350 grams of VOC per liter (g/l) to 250 g/l effective in 2004. Because the 250 g/l varnishes have begun to enter the market and the FIP allows approximately eight years for continued development and acceptance of the lower VOC product, EPA believes that the varnish limit is technically feasible. EPA does not believe it would be appropriate to increase the VOC limit to 450 g/l since the 350 g/l limit is already being successfully marketed by numerous coating manufacturers (e.g., Behr Process Corp. and Flecto Company) and in most California architectural coatings rules. The continued improvement and development of low VOCs coatings is discussed in the attached sample article "Synergism and lower VOCs" (American Paint & Coatings Journal, May 9, 1994).

Comment: The proposed limits less than 250 g/l for some categories are not adequately supported by the TSD. Specific categories mentioned included: flats; nonflats; primers, sealers, and undercoaters; traffic paints; and opaque stains and wood preservatives.

Response: Based on these comments, EPA has added additional information and explanation to the technical support document. In addition, limits for certain categories (e.g., traffic paints) have been revised to allow for a higher limit. EPA's response for each category mentioned by the commenter is provided below.

Comment: Flats (150 g/l and 50 g/l)

Response: The FIP regulation has been revised so that the limits are incrementally reduced from 250 g/l to 150 g/l in 2004. In CARB's September 1994 "Survey of Emissions from Solvent Use, Volume II: Architectural Coatings," The sales weighted average for waterborne flats, which account for over 99.9% of flat coating sales, was approximately 105 g/l. This indicates that the majority of flat coatings are already meeting the 150 g/l limit. EPA is not aware of any special circumstances or substrates where a flat coating greater than 150 g/l is needed. In addition, improvements continue to be made to the quality and performance of the coatings. The 2004 effective date provides additional time for the industry to transition to the lower VOC technology. The continued improvement and potential for lower VOCs coatings is discussed in the attached sample article "Formulating Low-Odor, Low-VOC Interior Paints" (Modern Paint and Coatings, March 1994).

Comment: Nonflats Not Otherwise Specified (150)

Response: The FIP regulation incrementally reduces the limits from 250 g/l to 150 g/l in 2004. The nonflat NOS category includes medium and low gloss coatings. Currently, areas in California which have an architectural coatings rule have a 250 g/l limit for nonflats. The proposed limit of 150 g/l would may result in most solventborne coatings, except for the 250 g/l high-gloss nonflats, being removed from the market. EPA believes that by 2004, the waterborne systems will adequately meet the performance requirements of the users. The 1990 sales weighted average for waterborne coatings with medium and low gloss nonflats was 162 g/l and 153 g/l. This indicates that a large percentage of medium and low gloss nonflat coatings are already meeting the 150 g/l limit. As the attached articles indicate, the technology continues to advance rapidly

and EPA believes that the 2004 effective date will allow adequate time for manufacturers to transition to the 150 g/l limit.

The exterior waterborne coatings are already generally recognized as performing better than solvent borne coatings. The waterborne interior nonflat coatings are already widely used and perform as well as or better than higher VOC coatings under most circumstances. Previously mentioned performance issues, such have blocking, have been reduced or overcome by continued improvements in the technology. In addition, improvements continue to be made to the quality and performance of the coatings. The continued improvement and potential for lower VOCs coatings is discussed in the attached sample article "EVA Maintains Paint Properties, Lower VOC" (Modern Paint and Coatings, August 1993). The 2004 effective date provides additional time for the industry to transition to the lower VOC technology.

Comment: Primers, Sealers, Undercoaters (150 g/l)

Response: EPA has revised the category and limits. Sealers have been placed into a separate category now titled "Sealers NOS" with a limit of 350 g/l. The primer and undercoater category limit has been revised from 150 g/l in 2003 to 275 g/l in 2004. A large percentage of low VOC, general purpose coatings are already being sold in the market. Waterbased systems account for approximately 60 percent of the 1990 sales with a sales weight average of less than 125 g/l. Numerous companies have recently introduced water reducible, low-VOC Direct-To-Metal product lines for metal substrates. EPA believes that the 2004 effective date for the 275 g/l limit will allow adequate time for transition to the low VOC technology.

Comment: Traffic Paints (125 g/l and 50 g/l)

Response: EPA has revised the 50 g/l limit to 100 g/l. The 125 g/l limit can be met by current waterborne technology. The current solventborne systems which are at 250 g/l contain 1,1,1-trichloroethane, which is being phased out because it is an ozone depleter. Based on conversations with professionals familiar with this category, it is expected that the 125 g/l waterborne systems can meet user needs. The 100 g/l limit effective in 2004 is expected to be met

through improvements to the current waterborne technology. EPA believes that the 2004 effective date allows adequate time for the transition to the 100 g/l coating. EPA will monitor the continued development of and issues relating to the 100 g/l coating.

Comment: Opaque Stains & Wood Preservatives (150 g/l)

Response: Waterborne acrylic latexes are already widely used for this category. CARB's survey indicates that the waterborne systems account for approximately 85% of the market and already achieve a sales weighted average VOC content of 133 g/l which indicates that the majority of the coatings are already below 150 g/l. The effective date for the 150 g/l of 2004 allows adequate time for the industry to transition to the lower VOC technology.

Local rules already corrected the problem.

Comment: FIPs were developed to correct program deficiencies and the architectural coating rules have already been corrected by the districts. Therefore, the FIP architectural coating rule is unnecessary.

Response: EPA is not promulgating the FIP architectural coatings measure to correct deficiencies. In addition, the FIP measure will not supplant local rules. Rather, it builds on local rules to achieve additional reductions. While some districts have revised their rules to correct EPA identified deficiencies, this does not preclude their inclusion in the FIP. On the contrary, almost all of the districts have yet to fully adopt the CARB SCM, which was adopted by CARB in 1989. The FIP measure was proposed because the architectural coatings category makes up a significant portion of the emissions inventory, additional VOC reductions are needed in the FIP areas, and the availability and continued development of low VOC coatings and technology demonstrated that the limits were feasible.

Comment: EPA does not have legal authority to put an architectural coating rule in FIP.

Response: EPA legal authority was described in section III.A.2 of the FIP proposal.

Statewide Measure: Unauthorized or Necessary?

Comment: EPA does not have the authority to adopt a statewide measure and a statewide measure is unnecessary.

Response: Comments from the FIP-area air pollution control districts and a coalition of environmental groups indicated support for a statewide measure. EPA's rationale for a statewide measure was described in the NPR at 59 FR 23316 and is discussed again under Section III.A.5. EPA believes that because of the close proximity of other major urban areas to the FIP areas, the measure would be substantially less effective if applied only to the FIP areas. In addition, because of the Agency's limited resources, EPA anticipates greater difficulty if faced with enforcing a rule only applicable in the FIP areas. Because of the larger volume of sales expected and the greater ease in marketing, a statewide measure is expected to reduce the cost of manufacturing low-VOC coatings for many manufacturers. Prior to the FIP proposal, many paint manufactures had indicated a preference for consistent limits within California. During CARB's adoption of its "Suggested Control Measure for Architectural Coatings," CARB stressed the importance of uniformity among districts. For these reasons EPA has chosen to promulgate a statewide architectural coatings measure.

However, as discussed in section III.A.4. of the preamble, a FIP is not intended to be a permanent solution for a state's air quality problems. The State currently does not have legal authority the regulate architectural coatings on a statewide basis. Nor has CARB indicated an interest in seeking legislation that would give the State such authority. Therefore, once the SIP is approved and the FIP rescinded, the uniformity created by the FIP rule will no longer exist. EPA believes that a potential solution to this dilemma could be for CARB to seek legislative authority to regulate architectural coatings on a statewide basis.

Comment: A statewide rule is a burden for areas already in attainment.

Response: EPA believes that the statewide rule is needed to insure the enforceability of the rule. As described above, most manufacturers have, in the past, expressed a preference for consistent limits.

The attainment areas in California would also be required to use low VOC coatings. Approximately 90% of the California population is currently residing in an ozone nonattainment area. Thus, the statewide measure has the potential to also benefit the areas of California which are in a nonattainment area. This would only become a burden if the lower VOC products are determined to be less preferable or less effective in those areas. EPA believes that the use of low VOC coatings does not equate to a burden. The lower VOC products are typically less hazardous, easier to use, less flammable, and easier to clean-up. The benefits of these products can balanced any perceived burden.

Comment: The FIP measure will impose severe anti-competitive impacts on small businesses.

Response: EPA is sensitive to the potential impact of the rule on small business. However, no suggestions were provided regarding how the rule could be amended to better accommodate small business.

EPA acknowledges that the rule might have a potentially negative impact on small businesses which rely heavily on marketing of high VOC coatings. EPA believes that the rule allows adequate time for small manufacturers to transition to lower VOC coatings. In addition, the assistance of resin suppliers will aid in the transition to lower VOC products.

Some small businesses believe that regulations can create an opportunity and/or benefit because they can adjust to the market quicker than their larger competitors. In addition, many small manufacturers serve niche markets which are not necessarily addressed by the larger manufacturers. EPA expects that these niche markets will remain available for the small businesses. EPA believes that the development of a small business assistance program may be appropriate given the potential impacts of the measure.

Comment: Supports statewide measure.

Response: EPA concurs, but will rescind the measure if adequate SIP measures are developed in the three FIP areas. As mentioned above, EPA believes that a potential solution to this dilemma could be for CARB to seek legislative authority to regulate architectural coatings on a statewide basis.

Section 183(e) Takes Precedent Over Section 110(c)

Comment: The commenter indicated that Section 183(e) of the Clean Air Act takes precedence over any other general provision of the Act allowing EPA to promulgate an architectural coatings measure.

Response: Section 183(e) requires that EPA issue a national regulation or a control techniques guideline (CTG) for certain consumer products, which will likely include architectural coatings. EPA believes that the FIP measure is not an attempt to issue a national regulation or CTG. As discussed at 59 FR 23290, EPA's authority under 110(c) allows EPA to act on behalf of the state under section 110(c); therefore, the FIP measure is analogous to a measure being adopted by the state. Because section 183(e) does not preempt a state from adopting an architectural coatings regulation, EPA, acting on behalf of the state, is not preempted by section 183(e) from promulgating an architectural coatings measure for the state. EPA is currently planning to propose a national architectural coatings rule in 1995 pursuant to section 183(e). Had this rulemaking been completed it may not have been necessary for the FIP to address architectural coatings separately.

Because architectural coating emissions make up a significant portion of the inventories, the FIP measure is needed to provide the necessary reductions for demonstrating attainment in the FIP areas. In addition, absent EPA's issuance of a source category listing and regulatory schedule under section 183(e) that sets the architectural coatings category for regulation by a specific date, EPA has not been in a position to credit emissions reductions expected from such regulation. Consistent with EPA's implementation of these section 183(e) obligations, EPA will evaluate the expected reductions from such a national rule and reevaluate the continued need for the FIP measure.

Comment: Reactivity-adjusted studies, as required by 183(e), have not been

made for the FIP rule.

Response: The Urban Airshed Model used by the districts includes consideration of reactivity in the modeling analysis. Therefore, reactivity has been taken into consideration through the UAM process. As described above, EPA does not believe that a separate reactivity based study of architectural coatings, as described under the section 183(e) language, is required for the FIP. The EPA, in this case, is acting on behalf of the state and the Act does not require a state to base its regulation on a reactivity adjusted study. If the section 183(e) outcome indicates that the FIP should be revised to incorporate a reactivity based strategy, EPA will reevaluate the FIP as necessary.

Environmental and Economic Impact Study Required

Comment: EPA should complete a separate environmental and economic study as required in section 183(e) and/or California law (i.e., the California Environmental Quality Act or "CEQA").

Response: As previously discussed, EPA's FIP action is not an attempt to meet its 183(e) obligation and is therefore not subject to the 183(e) requirements. Although EPA is acting on behalf of the state, EPA is not subject to the requirements of state law (e.g., CEQA). EPA has conducted the studies (i.e., Regulatory Impacts Analysis and Regulatory Flexibility Act Analysis) required of the FIP.

Costs

Comment: The costs and benefits of reformulated coatings should be evaluated.

Response: In the preamble (59 FR 23317) EPA specifically requested comment and technical information on previous or potential reformulation costs. No new information was submitted by any of the commenters. EPA estimates the cost to range from a savings to a cost of approximately \$12,000 per ton of VOC reduced. The benefits of reformulation to lower VOC coatings include but are not limited to: reduced user exposure to hazardous air pollutants, reduced hazardous waste, and reduced emissions of VOCs.

Section 182(e)(5) reductions

Comment: Further reductions from architectural coatings as required under 182(e)(5) must be conditioned on development of technology.

Response: The stationary and area source 182(e)(5) rules are scheduled for proposal in 2004 and adoption in 2005. EPA, along with the State and districts, will continue to monitor the development of the next generation of low VOC technologies. Zero VOC coatings are already in the market. As the future rules are developed, there will be the opportunity for industry and the regulators to work together and evaluate the state of the technology.

Alternative Reduction Approaches

Response: Very few substantive comments were received on the three potential economic incentive options described at 59 FR 23318. EPA will continue to analyze possible market-based mechanisms, such as fees, as a potential method for an enforceable yet flexible mechanism for meeting the coating limits.

Comment: Opposed to the concepts mentioned in the FIP proposal (i.e., Fees, Corporate Average VOC Limit, and Manufacturers Bubble) except where fees are allowed in lieu of compliance.

Response: The commenter opposed the use of a corporate average VOC emission limit or manufacturers bubble, and conditionally supported a fee program. The commenter did support an exceedance fee in lieu of compliance with VOC limits, but wanted assurances that the fee payment would protect against federal, state, or local enforcement. EPA can not provide such assurances because the FIP measure does not replace current SIP rules or preclude local enforcement of SIP rules.

Comment: Opposes CAVE and manufacturers bubble.

Response: EPA agrees that this concept needs to be further evaluated for its

benefits and drawbacks. EPA has not included a CAVE or manufacturers bubble program in the final FIP, but will continue to work with the state, districts, and interested parties in order to further evaluate these and other potential market-based options.

Comment: Supports market incentives (e.g., trading) in FIP areas.

Response: Very few comments were received which indicated support for a market-based trading measure which included architectural coatings. As a result EPA has not including an emissions trading element in the FIP architectural coatings rule.

Other Comments and Recommended Changes

Comment: Test methods should be consistent throughout the FIP.

Response: EPA has reviewed the sections mentioned by the commenter which reference certain test methods proposed. These sections have been revised for consistency throughout the FIP.

Comment: Recommend that all ASTM methods be considered acceptable and that approval dates not be included.

Response: Because enforcement of a limit or standard is determined by the appropriate ASTM method, it is important that only EPA approved methods and their approval date be included in the appropriate rule.

Comment: The low solids stain definition should be revised.

Response: EPA concurs and has revised the definition.

Comment: The definitions for waterborne and solventborne differ from those discussed in the Reg Neg.

Response: Because these definitions are no longer needed, they have been deleted from the rule.

Comment: Subsections (c)(1) and (c)(2) need to include a grandfathering clause.

Response: EPA believes the grandfathering provision in section (c)(4) adequately addresses this comment.

Comment: EPA should specify where at EPA manufacturers must file code explanations.

Response: EPA anticipates that the location will be determined at a later date. Manufacturers will be notified directly by EPA or in the Federal Register.

Comment: EPA should list aerosol paints as exempt from the architectural coatings rule.

Response: EPA believes that the rule does not need to be revised. It is clear from the fact that there is a rule specifically for aerosol paints that they are not regulated in the architectural coatings rule.

Comment: A division sign is needed between weights and volumes in "Grams of VOC per Liter of Coating Less Water and Less Exempt Compounds."

Response: The equation has been corrected.

Comment: For enforceability, "that are specifically formulated for and" should be added to definition of "Specialty, Primers, Sealers, and Undercoaters."

Response: This revision has been incorporated.

Comment: Add a calculation method for "low-solid stain."

Response: This revision has been incorporated.

Comment: Add SCAQMD Method 311-91 for measurement of metal content and ASTM D 1613 for acid content.

Response: These test methods have been incorporated.

Comment: Delete the exemption of tint bases from the VOC content calculation.

Response: This revision has not been incorporated at this time pending further study.

Appendix A

Summary of Expected Reductions

										ſ
			NFR Red	NFR Reduction Estimates	afes		NPR Re	MPR Reduction Estimates	nafas	
Category	Ē	1990 Survey (tpd)	constant solids	FIP area adjustment	constant	FIP area adjustment	1988 Survey (tpd)	constant solids	constant gallons	
Below-Ground Wood Preserv	350	0.2	0.1		c		90			
Bond Breakers	320	0.0	00		0.0		o.o	5	5	
Clear Wood Finishes:										
Lacquer	320	9.9	5.0	0.3	1.1	0.0	12.0	0.6	5.5	
Sanding Sealers	320	2.9	2.3	0.3	2.3	0.0			;	
Varnish	2 2	4.0	2.6	6.0	2.6	0.2	3.8	2.1	1.4	
	9 5		C.3		0.3		1.0	0.1	 1:0	
Dry rog coatings	25	4.0.4	0.2	į	0.2		0.5	0.3	0.2	
Flats Non-Glate: Linth Olone	2 6	16.4	4 4 5 6	0.4 7.0	4.9		17.5	7.0	3,9	
Non-Flats, right Gloss	8 6	1 0	D (χ. ·	4.	4.				
Romel Indercostere	3	C'/L	2.6	J.9	6.1	- :	24.7	6.8	5.4	
Fire-Retardant							2.4	1.6	4. 4.	
Clear	320	0.0	0.0		00		Č	Ċ	č	
Pigmented	350	0.1	00		0.0		- -	9	- -	
Form-Release Comp	250	0.0	0.0		0.0					
Graphic Arts (Sign)	425	2.5	0.0		00		0	č	ć	
Low-Solids Stains	120		})		7.0	ö	0.0	
Industrial Mantenance			•							
Anti-Graffiti Coat	275	0.0	0.0		0.0					
Antenna	420									
Anti-fouling	275									
Chalkboard Resurfacers	450									
High Temp Indus	420									
Other	275	12.4	5.5	6.0	2.5	0.2	16.1	7.0	4.3	
Nuclear Power Plant	380								!	
Impact immersion	8									
Flow Coating	450				•					
Heat Reactive Coatings	450	;								
Magnesite Cement	န္တ န	e 0 0	0.1		0,1		0.4	0.2	0.1	
Masuc resture	3 5		7.0		0.0		1.6	0.1	0.1	
Metallic rigineried	5 6	c	 		0.5		5.5	0.7	9.4	
Opposition Station	7 4		- c	ć	9 (•	0.1			
Openie Most Dropp with an	3 5	7.0	<u>.</u>	S 6	0.0	 	2.8	1 .0	6.0	
Opaque Wood Flessivanves	2 6	9 6	0.0	0.0	0.0	0:0	0.3	0.2	0.2	
Primare Soalare & Indernators	5 6 8 6	, c		7	0.0	ć	0.2	 	0.1	
Specially Primer Sealer & Undercoster*	35.5			<u>.</u>	0.0	8.0	ω, . ω, .	4.	3.2	
Onick Dry Enamels	3 5	c	*		,		L. 1	4.0	0.3	
Ouick Day Briman Seators & Hadarage	3 4	7. 7	- u	ć	Ξ ;	,	c:/	3.8	2.8	
Roof Costings. Sealers, & Olidercoal	א ה ה	± ₹		C.O	7.0	0.1	4.4	တ္	3.3	
Committee Continue	9 6	4.4		(r.o		8.5	2.5	4:	
Semi-transparent Stains Semi-transparent & Clear	25		2.2	2.2	7.	د .	9.9	2.2	1.3	
mood prospering a	OEC.	•	ç	ć	ć		,	1		
COATION DOOR TOOM	Š	2	? ?	S.O	7.0	0.2	2.2	0.8	0.5	

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			1							
Category		1990 Survey (Ipd)	NFK Reconstant	NFK Keduction Estimates constant FIP area con solids adjustment ga	rafes constant gallons	FIP area adjustment	NPR Re 1988 Survey (tpd)	NPR Reduction Estimates 88 Survey constant const (tpd) solids galit	mates constant gallons	
Shellac Clear	009	0.2	0.1		0.0		0.5		0	
Shellac Pigmented	200	0.5	0.2		0.1		?	; .	.	
Swimming Pool Coatings	340	0.0	0.0		0.0		0.3	0.0	0.0	
Swimming Pool R&M	340	0.0	0.0		0.0		}	!	!	
Tile-like Glaze							0.2	0.1	1.0	
Traffic Paints	5	5.2	3.8	2.0	2.9	1:	3.4	2.9	26	
Waterproof Mastic Coating							0.1	00	00	
Waterproofing Sealers *	9	3.2	6.0	60	0.7	0.7	1.0	0.3	00	
Waterproofing Sealers Pigmented	320	0.3	0.1	0.1	0.0	0'0		}	ļ	
Other	250	1.0	9.0		0.3					
Statewide Reduction Estimate		106.9	43.5	13.8	33.2	7.4	131.1	27.7	40.0	
Statewide Percent Reduction			41%		31%			44%	30%	
NOTES:										

Estimates are in tons per day based on survey results; these are not representative of planning inventory estimates and do not include thinner/clean-up emissions; Estimates rounded to nearest 0.1.

FIP area adjustment reflects impact of current SIP limits on statewide reduction estimate...

Revised reductions minus reductions from current measures.

Totals Estimated reductions not applicable to FIP areas	106.9	43.5 <u>13.8</u> 29.7	33.2 7.4 25.8	131.1	54.8	38.2
Revised Percent reduction for FIP areas		28%	24%		42%	29%

Reductions for each area will depend on requirements in the current district rule.

Because each FIP area has an architectural coatings rule, the FIP area reduction estimates are expected to be less than estimates above for statewide.

An attempt was not made to calculate reductions from each category for each FIP area.

Based on these factors, FIP Area reductions should range from 24-28%; statewide reductions should range from 31-41%

Appendix B

This is an unofficial reprint of the FIP architectural coatings rule.

Most if not all significant changes are shaded or crossed-out.

Note: This is an unofficial reprint of the FIP architectural coatings rule. Most if not all significant changes are shaded or crossed-out.

§52.2959 Architectural coatings.

- (a) Applicability. This section applies to any person who supplies, sells, offers for sale, applies, solicits the application of, or manufactures for use any architectural coating used in California.
- (b) <u>Definitions</u>. For the purposes of this section, the following definitions shall apply. All terms not defined herein shall have the meaning given them in §52.2950.

Antenna coatings are coatings applied to equipment and associated structural appurtenances which are used to receive or transmit electromagnetic signals.

Anti-fouling coatings are coatings applied to submerged stationary structures and their appurtenances to prevent or reduce the attachment of marine or freshwater biological organisms, including, but not limited to, coatings registered with the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (7 USC 136, et seq.) and nontoxic foul-release coatings.

Anti-graffiti coatings mean clear or opaque high performance coatings specifically labeled as anti-graffiti coatings and applied to interior and exterior walls, doors, partitions, fences, signs and murals to deter adhesion of graffiti and to resist repeated scrubbing and exposure to harsh solvents, cleansers, or scouring agents used to remove graffiti.

Appurtenances are accessories to an architectural structure, including, but not limited to: hand railings, cabinets, bathroom and kitchen fixtures, fences, rain-gutters and down-spouts, window screens, lamp-posts, (heating and air conditioning) equipment, other mechanical equipment, large fixed stationary tools and concrete forms.

Architectural coatings are any coatings applied to stationary structures and their appurtenances, to mobile homes or portable buildings, to pavements, or to curbs.

Below-ground wood preservatives are coatings formulated to protect below-ground wood from decay or insect attack and registered with the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (7 USC 136, et seq.).

Bituminous coatings materials are black or brownish coating materials, soluble in carbon disulfide, consisting mainly of hydrocarbons and which are

obtained from natural deposits, or as residues from the distillation of crude petroleum oils, or of low grades of coal.

Bond breakers are coatings applied between layers of concrete to prevent the freshly poured top layer of concrete from bonding to the substrate over which it is poured.

<u>Chalkboard resurfacers</u> are coatings formulated and recommended for application to chalkboards to restore a suitable surface for writing with chalk.

<u>Clear wood finishes</u> are clear and semi-transparent coatings, including lacquers and varnishes, applied to wood substrates to provide a transparent or translucent solid film.

Colorants are solutions of dyes or suspensions of pigments.

<u>Concrete-curing compounds</u> are coatings applied to freshly poured concrete to retard the evaporation of water.

<u>Dry-fog coatings</u> are coatings which are formulated only for spray application so that when sprayed, overspray droplets dry before falling on floors and other surfaces.

Exempt compounds mean compounds listed as having negligible photochemical reactivity under the definition of "volatile organic compounds" in 40 CFR part 51, § 51.100.

Fire retardant coatings are coatings which have a flame spread index of less than 25 when tested in accordance with ASTM E 84-91a Standard Test Method for Surface Burning Characteristics of Building Materials (incorporated by reference as specified in 40 CFR 52.3002) after application to Douglas fir according to the manufacturer's recommendations.

Flat coatings are coatings which register gloss less than 15 on an 85° meter or less than five on a 60° meter, according to American Society for Testing and Materials Method D 523, Standard Test Method for Specular Gloss.

Flow coatings are coatings which are used by electric power companies or their subcontractors to maintain the protective coating systems present on utility transformer units.

Form-release compounds are coatings applied to a concrete form to prevent the freshly poured concrete from bonding to the form. The form may consist of wood, metal, or some material other than concrete.

Grams of VOC per liter-Low solids means the weight of VOC per volume of material and can be calculated by the following equation:

Where:

W_s = weight of volatile compounds, in grams;

Grams of VOC per Liter--Low Solids =
$$\frac{Ws - Ww - Wec}{Vm}$$

 W_w = weight of water, in grams;

Wee e weight of exempt compounds, in grams; and

 V_m = volume of material, in liters.

This equation may be used to calculate the VOC content of a low solid stain.

Grams of VOC per liter of coating, less water and less exempt compounds is the weight of VOC per combined volume of VOC and coating solids and can be calculated by the following equation:

Grams VOC/
$$\ell$$
 of Coating =
$$\frac{(W_s - W_w - W_{ec})}{(V_m - V_w - V_{ec})}$$

 W_s = Weight of VOC in grams

W_w = Weight of water in grams

W_{ec} = Weight of exempt compounds in grams

 V_m = Volume of coating in liters V_w = Volume of water in liters

V_{ec} = Volume of exempt compounds in liters

Graphic arts coatings (Sign Paints) are coatings formulated for and hand-applied by artists using brush or roller techniques to indoor and outdoor signs (excluding structural components) and murals, including lettering enamels, poster colors, copy blockers, and bulletin enamels.

Heat reactive coatings mean high performance phenolic based coatings requiring a minimum temperature of 191°C (375°F) to 204°C (400°F) to obtain complete polymerization or cure. These coatings are formulated and recommended for commercial and industrial use to protect substrates from degradation and maintain product purity in which one or more of the following extreme conditions exist:

- Continuous or repeated immersion exposure to 90 to 98 percent sulfuric acid or oleum;
- (2) Continuous or repeated immersion exposure to strong organic solvents;
- (3) Continuous or repeated immersion exposure to petroleum processing at high temperatures and pressures; and
- (4) Continuous or repeated immersion exposure to food or pharmaceutical products which may or may not require high temperature sterilization.

High-temperature industrial maintenance coatings are industrial

maintenance coatings formulated for and applied to substrates exposed continuously or intermittently to temperatures above 400°F.

Impact immersion coatings are industrial maintenance coatings applied to steel structures subject to immersion in turbulent, debris-laden water. These coatings are specifically resistant to high-energy impact damage caused by floating ice or debris.

<u>Industrial maintenance coatings</u> are high performance coatings formulated for and applied to substrates in industrial, commercial, or institutional situations that are exposed to one or more of the following extreme environmental conditions:

- (1) immersion in water, wastewater, or chemical solutions (aqueous and non-aqueous solutions), or chronic exposure of interior surfaces to moisture condensation;
- (2) acute or chronic exposure to corrosive, caustic or acidic agents, or to chemicals, chemical fumes, chemical mixtures, or solutions;
- (3) repeated exposure to temperatures in excess of 250 degrees Fahrenheit;
- (4) repeated heavy abrasion, including mechanical wear and repeated scrubbing with industrial solvents, cleaners, or scouring agents; or
- (5) exterior exposure of metal structures. Industrial maintenance coatings are not for residential use or for use in areas of industrial, commercial, or institutional facilities such as office space and meeting rooms.

<u>Lacquers</u> are clear wood finishes, including clear lacquer sanding sealers, formulated with nitrocellulose or synthetic resins to dry by evaporation without chemical reaction.

Low-solids stain or wood preservative means a waterborne wood stain or wood preservative containing one pound or less of solids per gallon of material and containing water as at least half the volatile portion of the liquid coating.

Magnesite cement coatings are coatings formulated for and applied to magnesite cement decking to protect the magnesite cement substrate from erosion by water.

Mastic coatings are coatings formulated to cover holes and minor cracks and to conceal surface irregularities, and applied in a thickness of at least 10 mils (dry, single coat).

Metallic pigmented coatings are coatings containing at least 0.4 pound of elemental metallic pigment per gallon (50 grams/liter of coating as applied) or non-bituminous coatings which are formulated with metallic pigment.

Multi-colored coatings are coatings which exhibit more than one color when applied and which are packaged in a single container and applied in a single coat.

Non-flat coatings are coatings which register gloss of 15 or greater on an 85° meter or five or greater on a 60° meter and which are identified on the label as a gloss, semigloss, or eggshell enamel coating.

Non-flat high gloss coatings are coatings which register gloss of 70 or greater on a 60° meter and which are identified on the label as a high gloss enamel coating.

NOS means not otherwise specified.

Nuclear power plant coatings mean any protective coating used to seal porous surfaces such as steel (or concrete) that otherwise would be subject to intrusion by radioactive materials. These coatings must be resistant to long-term (service life) cumulative radiation exposure (American Society for Testing and Materials D4082-83, incorporated by reference as specified in 40 CFR 52.3002), relatively easy to decontaminate (American Society for Testing and Materials D4256-83, incorporated by reference as specified in 40 CFR 52.3002), and resistant to various chemicals to which the coatings are likely to be exposed (American Society for Testing and Materials 3912-80, incorporated by reference as specified in 40 CFR 52.3002). General protective requirements are outlined by the Department of Energy (formerly U. S. Atomic Energy Commission Regulatory Guide 1.54).

Opaque stains are all stains that are not classified as semitransparent stains.

Opaque wood preservatives are all wood preservatives not classified as clear or semitransparent wood preservatives or as below-ground wood preservatives and are registered with the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (7 USC 136 et seq.).

Quick-dry enamels mean non-flat coatings that: are capable of being applied directly from the container under normal conditions, with ambient temperatures between 16°C (60 F°) and 27°C (80 F°); when tested in accordance with ASTM D 1640 (incorporated by reference as specified in 40 CFR 52.3002) are set to touch in two hours or less, be tack free in four hours or less, and dry hard in eight hours or less by the mechanical test method; shall have a dried film gloss of 70 or above on a 60 degree meter.

Residential use is use in areas where people reside or lodge including, but not limited to single and multiple family dwellings, condominiums, mobile homes, apartment complexes, motels, and hotels.

Roof coatings are coatings formulated for application to exterior roofs and for the primary purpose of preventing penetration of the substrate by water, or reflecting heat and reflecting ultraviolet radiation. Metallic pigmented roof coatings which qualify as metallic pigmented coatings shall not be considered to be in this category, but shall be considered to be in the metallic pigmented coatings category.

<u>Sanding sealers</u> are clear wood coatings formulated for and applied to bare wood for sanding and to seal the wood for subsequent application of varnish. To be considered a sanding sealer a coating must be clearly labelled as such.

<u>Sealers</u> are coatings applied to substrates to prevent subsequent coatings from being absorbed by the substrate, or to prevent harm to subsequent coatings by materials in the substrate.

<u>Semitransparent stains</u> are coatings which are formulated to change the color of a surface but not conceal the surface.

<u>Semitransparent wood preservative</u> are wood preservative stains formulated to protect exposed wood from decay or insect attack by the addition of a wood preservative registered with the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (7 USC 136 et seq.) and which change the color of a surface but do not conceal the surface, including clear wood preservatives.

<u>Shellacs</u> are clear or pigmented coatings formulated solely with the resinous secretions of the lac beetle (laccifer lacca), thinned with alcohol, and formulated to dry by evaporation without a chemical reaction.

Solicit is to require for use or to specify, by written or oral contract.

Specialty primers, sealers, and undercoaters means primers, sealers, and undercoaters that are specifically formulated for and used only to perform one of the following functions: repair fire, smoke or water damage; neutralize odor; block stains; block efflorescence; condition chalky surfaces; or coat acoustical materials without affecting their acoustical abilities.

Swimming pool coatings are coatings specifically formulated to coat the interior of swimming pools and to resist swimming pool chemicals.

Swimming pool repair coatings are chlorinated rubber based coatings used for the repair and maintenance of swimming pools over existing chlorinated rubber based coatings.

<u>Tint base</u> is an architectural coating to which colorants are added.

<u>Traffic coatings</u> are coatings formulated for and applied to public streets, highways, and other surfaces including, but not limited to curbs, berms,

driveways, airport runways, and parking lots.

<u>Undercoaters</u> are coatings formulated and applied to substrates to provide a smooth surface for subsequent coats.

<u>Varnishes</u> are clear wood finishes formulated with various resins to dry by chemical reaction on exposure to air.

<u>Volatile organic compound</u> or <u>VOC</u> means any compound of carbon, other than those organic compounds that the Administrator has excluded in 40 CFR part 51, § 51.100 from this definition.

<u>Waterproofing sealers</u> are colorless coatings which are formulated for the sole purpose of preventing penetration of porous substrates by water and which do not alter surface appearance or texture.

- (c) Requirements.
- (1) Except as provided in paragraphs (c)(2), (c)(3), (c)(4) and (c)(5) of this section, after May 15, 1997, no person shall manufacture, supply, sell, offer for sale, blend, repackage, apply, or solicit the application for use within California any architectural coating which contains more than 250 grams of volatile organic compounds per liter of coating (excluding water and exempt solvents, and any colorant added to tint bases).
- (2) Except as provided in paragraphs (c)(3), (c)(4) and (c)(5) of this section, no person shall manufacture, supply, sell, offer for sale, blend, repackage, apply, or solicit the application for use within California any architectural coating listed in the Table of Standards which contains volatile organic compounds (less water and exempt solvents, and excluding any colorant added to tint bases) in excess of the corresponding limit and date specified in the table.

<u>VOC Limit Table of Standards</u>
Grams of VOC Per Liter less Water And Exempt Compounds

Category	5/15/1997	1/1/2000	1/1/2004
Antenna Coating	420	340	
Anti-Fouling Coating	400	340 .	350
Anti-Graffiti Coating	350	275	
Bond Breakers	350		
Chalkboard Resurfacers	450		420
Clear Wood Finishes			

Varnish	350		250
Sanding Sealers	350		
Lacquer Sanding Sealers	680	350	
Lacquer	680	350	
Concrete-Curing	350	250	
Dry-Fog Coatings	400		250
Fire Retardant Coatings			
Clear	350		
Pigmented	350		
Flats	250	200 150	150 50
Flow Coating	650		420
Form Release Compounds	250		
Graphic Arts Coatings	500	425	
Heat Reactive Coatings	420		
High Temperature	550	420	
Impact Immersion	420	340	340
Industrial Maintenance Coatings, NOS	350 340	,	275
Magnesite Cement	600	500	500
Mastic Coatings	300		
Metallic Pigmented	500	450	340
Multi-Color Coatings	420		
Non-Flats, NOS	250		150
Non-Flats - High Gloss	250		
Nuclear Power Plant	380	340	
Pretreat Wash Primers	780	420	

Primers , Sealers and Undercoaters	350		275 150
Quick-Dry Enamels	400	250	
Specialty Primers and Undercoaters	350		
Sealers NOS	350		·
Roof Coatings	250		
Shellac Clear	650	600	
Shellac Pigmented	550	500	
Stains and Wood Preservatives			
Semi-Transparent	350		
Opaque	350 250	200	150
Clear	350		
Below-Ground	350		
Low-solids	120		
Swimming Pool Coatings	. 340		A
Swimming Pool Repair and Maintenance Coatings	650	340	
Traffic Paints	150	125	100 50
Waterproofing Sealers	400		

- (3) If anywhere on the container of any coating listed in the Table of Standards, on any sticker or label affixed thereto, or in any sales or advertising literature, any representation is made that the coating may be used as, or is suitable for use as a coating for which a lower VOC standard is specified in the Table of Standards or in paragraph (c)(1) of this section, then the lowest VOC standard shall apply. This requirement does not apply to the representation of the following coatings in the manner specified:
- (i) High-temperature industrial maintenance coatings, which may be represented as metallic pigmented coatings for use consistent with the definition

of high temperature industrial maintenance coatings;

- (ii) Metallic pigmented coatings, which may be recommended for use as primers, sealers, undercoaters, roof coatings, or industrial maintenance coatings; and
 - (iii) Shellacs.
- (4) Sale or application of a coating manufactured prior to the effective date of the corresponding standard in the Table of Standards, and not complying with that standard, shall not constitute a violation of paragraph (c)(2) of this section until eighteen months after the effective date of the standard.
- (5) Sale or application of a coating in a container of one quart capacity or less shall not constitute a violation of paragraph (c)(1) or (c)(2) of this section until January 1, 200.
- (6) All VOC-containing materials shall be stored in closed containers when not in use. In use includes, but is not limited to: being accessed, filled, emptied, or repaired.
 - (d) Administrative Requirements.
- (1) Containers for all coatings subject to this section shall display the date of manufacture of the contents or a code indicating the date of manufacture. The manufacturers of such coatings shall file with the EPA an explanation of each code.
- (2) Containers for all coatings subject to the requirements of this section shall carry a statement of the manufacturer's recommendation regarding thinning of the coating. This recommendation shall not apply to the thinning of architectural coatings with water. The recommendation shall specify that the coating, is to be employed without thinning or diluting under normal environmental and application conditions, unless any thinning recommended on the label for normal environmental and application conditions does not cause a coating to exceed its applicable standard.
- (3) Each container of any coating subject to this section shall display the maximum VOC content of the coating, as applied, and after any thinning as recommended by the manufacturer. VOC content shall also be displayed as grams of VOC per liter of coating (less water and exempt solvent, and excluding any colorant added to tint bases). VOC content displayed may be calculated using product formulation data, or may be determined using the test method in paragraph (e) of this section.
- (4) The labels of all industrial maintenance coatings shall include the statement "Not for Residential Use," or "Not for Residential Use in California," prominently displayed.

- (e) <u>Test Method</u>. The VOC content of a coating subject to the provisions of this section shall be determined using the following procedures:
- (1) Method 24 of 40 CFR part 60, appendix A, shall be used in the determination of volatile matter content, water content, and density, volume solids, and weight solids of paint, varnish, lacquer or related surface coatings.
- (2) The measurement of exempt solvents shall be determined using ASTM Test Method 4457-85 (incorporated by reference as specified in 40 CFR 52.3002).
- (3) Measurement of dry time for quick-dry enamels shall be done using ASTM D 1640-89, Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature (incorporated by reference as specified in 40 CFR 52.3002);
- (4) Measurement of metal content of metallic pigmented coatings shall be done using the SCAQMD Method 311-91, Analysis of Percent Metal in Metallic Coatings by Spectrographic Method (incorporated by reference as specified at 40 CFR 52.3002).
- (5) Measurement of acid content of pretreatment wash primers shall be done in accordance with ASTM Method D 1613-85 (modified) (incorporated by reference as specified in 40 CFR 52.3002).
- (6) Measurement of gloss shall be doen using ASTM D 523, Standard Test Method for Specular Gloss (incorporated by reference as specified in 40 CFR 52.3002).
 - (f) <u>Exemptions</u>.
 - (1) The provisions of this section shall not apply to:
- (i) Until January 1, 20043, architectural coatings in containers having capacities of one quart; or
- (ii) Architectural coatings sold in California for shipment outside of the state or for shipment to other manufacturers for repackaging; or
 - (iii) Emulsion type bituminous pavement sealers.
- (2) Coatings subject to the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act are exempt from the labeling requirements listed under paragraph (d) of this section.

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Attachments

- 1. California Air Resources Board. "Survey of Emissions from Solvent Use, Volume II: Architectural Coatings, Final Report". September 1994.
- 2. California Air Resources Board. "Field Investigation on Thinning Practice: During the Application of Architectural Coatings in Selected Districts in California." December, 1991
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- 4. Salem, Linda S. and Robert J. Klepser. "High-Solids Coatings For Steel Close the Performance Gap." *Modern Paint and Coatings* (February 1992): 34-38.
- 5. Currie, Bill. "EVA Maintains Paint Properties, Lowers VOC." *Modern Paint and Coatings* (August 1993): 34-40.
- 6. "Water-Borne Technologies for Wood Floor Finishes." *Modern Paint and Coatings* (March 1993): 40-42.
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- 8. Coogan, Dr. Richard G., James J. Bilancieri and Gail Pollano. "Senergism and lower VOCs: Water-borne urethane/acrylic latex blends." *American Paint & Coatings Journal* (May 9, 1994): 49-54.
- 9. Johnson, Rich. "Acrylic lacquer water-borne dispersions: Very low VOCs, lacquer-type performance." *American Paint & Coatings Journal* (May 9, 1994): 55-58.

- 10. "Historic Lighthouse Showcases Water-Based Maintenance Paint." *Modern Paint and Coatings* (June 1989): 70-74.
- 11. Peart, John, and Robert A. Kogler, Jr. "Environmental Exposure Testing of Low VOC Coatings for Steel Bridges." *Journal of Protective Coatings & Linings* (January 1994): 60-69.
- 12. "Ventura County Air Pollution Control District Response to Southern California Paint Manufacturer's Association Regarding VCAPCD Rule 74.2."

Survey of Emissions from Solvent Use

Volume I: Aerosol Paints Volume II: Architectural Coatings

Final Report

Contract No. A132-086

Prepared for:

California Air Resources Board Research Division 2020 L Street Sacramento, California 95814

Prepared by:

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September 1994

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Volume II: Architectural Coatings

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The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their sources, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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ABSTRACT

The California Air Resources Board (ARB) is authorized under the California Health and Safety Code and Title 17 to require submission of information needed to estimate atmospheric emissions and to carry out its statutory responsibilities. In 1993, the ARB conducted surveys of sales in California for both aerosol paints and architectural coatings. Battelle processed the survey data and prepared a computer database, reviewed the data for accuracy and completeness, contacted representatives of participating companies to resolve problems, and summarized the results. The results will help the ARB understand the marketplace for these source categories, and evaluate the emissions and cost impacts of proposed emission control measures.

Battelle analyzed data from ARB's fourth survey of companies that sold architectural and industrial maintenance coatings (for the year 1990). The 174 companies that responded reported California sales of 77 million gallons, with VOC emissions estimated at 39,100 tons per year. The 25 largest companies were responsible for most of the sales. Sales were reported in 33 coating categories, and distributions were provided based on VOC content. Close to half the sales were in the flat paint category, and water-borne coatings constituted about three-quarters of all sales. However, solvent-borne VOC emissions were more than twice those from water-borne coatings. Acrylic and vinyl resins were used mainly for water-borne coatings, while alkyd resins were used mainly for solvent-borne coatings.

Battelle attempted to calculate the potential emission reductions that may result from full implementation of the "Suggested Control Measure" (SCM) developed by ARB and CAPCOA in 1989. The calculations were complicated by the fact that the manufacturers of some coatings recommend thinning with solvent before application. Depending upon the calculation method chosen, roughly 20 to 30 percent of the emissions from solvent-borne coatings may be eliminated by implementation of the SCM.

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INTRODUCTION

This report presents statistical results from a survey, conducted by the California Air Resources Board (ARB), of architectural coatings manufacturers and distributors who sold Architectural and Industrial Maintenance (AIM) coatings in California in 1990. This is the fourth such survey conducted since 1980 to collect data on the composition and sales of architectural coatings sold in the State for the purpose of estimating atmospheric emissions from these products.

These surveys have been undertaken to help the ARB and local air quality management and air pollution control district staff track the volatile organic compound (VOC) emissions from architectural coatings, and also to provide information to assist in the development and implementation of regulations to reduce the VOC emissions from architectural coatings. Architectural coatings have been regulated in California since the late 1970s. In 1977 the ARB approved a model rule which formed the basis for many district regulations over the ensuing years. This model rule was revised in 1985 and again in 1989, at which time the rule was referred to as a "suggested control measure." This report, in addition to providing information on the sales and emissions of coatings sold in the State during 1990, also contains estimates of the potential emission reductions that may be achieved under the 1989 ARB-CAPCOA Suggested Control Measure For Architectural Coatings.

MATERIALS AND METHODS

THE SURVEY

In February, 1993, the ARB mailed survey questionnaires to companies that potentially sold architectural coating products in California during 1990. The mailing list has been expanding since the initial survey was conducted by ARB in 1980. Original sources for the mailing list include the Golden Gate Society for Coatings Technology, Golden Gate Paint and Coating Association, Southern California Paint and Coatings Association, Los Angeles Society for Coating Technology, South Coast Air Quality Management District, and the National Paints and Coatings Association. Companies are also added to the mailing list when they contact ARB for information about regulations, or are identified in the course of ARB's regulation development efforts.

The ARB received 179 completed questionnaires as of May 1, 1994. However, this number was reduced to 174 after consolidating duplicate information and eliminating companies that did not sell coatings in California. The number of companies responding to the 1988 survey conducted by the ARB was 130, ten fewer than the number responding in 1984. Table 1a contains the names of 66 participating companies with headquarters in California (based on reported mailing address), and Table 1b lists the names of 108 participating companies located in other U.S. states. Seventy-six companies were identified as small businesses, with annual sales of less than \$5 million and fewer than 100 employees.

Information requested from the companies included company address, contact person, company size (annual sales and number of employees), and marketing classification (interstate, statewide, regional). Product information requested includes coating category, sales (large and small containers), type of application (interior/exterior, general/special substrate), product composition (carrier technology, resins used, percent solids, and VOC content). A copy of the survey questionnaire mailed to the companies is provided in Appendix B.

1990 ARB AIM Coating Survey

Table 1a. California Based Companies Reporting 1990 Sales of Architectural and Industrial Maintenance Coatings

AC Products, Inc.

Ameritone Paint Corporation

Ameron PCD

Behr Process Corporation

Benjamin Moore & Company

Bithell, Inc. / Virtrochem

Cal Western Paints, Inc.

Contract Coatings Corporation

Corchem Corporation

D. J. Simpson Company, Inc. DBA Simpson Coatings Group, Inc.

Davis Colors

Davlin Paint Company

Decrattend Paints

Deft, Inc.

Devoe Coatings Co.

Duckback Products, Inc.

Dunn-Edwards Corporation

Early American Paint & Varnish Company

Ellis Paint Co.

Epmar Corporation

Epoxylite Corporation

Evr-Gard Coatings

Fine Line Paint Corp.

Flamon Chemical Company

Frazee Industries, Inc.

Flecto Company, Inc.

Fuller - O'Brien Paints (The O'Brien Corporation)

Guardsman Products, Inc., Coatings Group

Henry Company

Hill Brothers Chemical Company

Hoffmann Paint Manufacturing Company

J. S. Williams & Sons

Kelly-Moore Paint Company, Inc.

L. M. Scofield Company

Lahabra Products, Inc.

Life Paint Company

Lyle Van Panen Company, Inc.

Major Paint Company

Morton International, Inc.

Nonon & Son of California, Inc.

Old Quaker Paint Company

Parks Corporation

Performance Coatings, Inc.

Pervo Paint Company

Pierce & Stevens Corporation

Pioneer Coatings Co.

Ponderosa Paint Co.

Preserva-Products, Inc.

Pride Paint Company

R. J. McGlennon Company, Inc.

Samuel Cabot, Inc.

San Luis Paints

Scotch Paint Corp.

Sinclair Paint Company / Division of Insilco Corp.

Smiland Paint Company

Southwest Division, Witco Corporation

Spectra-Tone Paint

Surface Protection Industries, Inc.

T. J. Westlund, Inc., DBA Humboldt Paint Factory

Textured Coatings of America

Tresco Paint Company, Inc.

Triangle Coatings

U.S. Cellulose Co., Inc.

Universal Paint Corp.

W. R. Meadows of California, Inc.

Western Colloid Products

1990 ARB AIM Coating Survey

Table 1b. Non-California Based Companies Reporting 1990 Sales of Architectural and Industrial Maintenance Coatings

Absolute Coatings, Inc.

Akzo Coatings, Inc. - Georgia

Akzo Coatings, Inc. - Michigan

Alfa Ink Division

American Safety Technologies, Inc.

Automotive Finishes, Inc.

Briner Paint Manufacturing Co., Inc.

California Products Corporation

Carbolineum Wood Perserving Co.

Champion Coarings

Chase Products Company.

Childers Products Company

Coatings for Industry, Inc.

Consumers Paint Factory, Inc.

Continental Products Company

CRC Industries, Inc.

Crescent Bronze Powder Company, Inc.

Daly's, Inc.

Dampney Company, Inc.

DAP, Inc.

Darworth Company

Dexter Packaging Products Division

Dyco Paints, Inc.

Dynatron / Bondo Corporation

E.S.P., Inc.

Enerfab Corporation

Euclid Chemical Company

Fields Corporation / American Tar Company

Flame Control Coatings, Inc.

Frost Paint & Oil Corporation

Gaco Western, Inc.

Gardner Asphalt Corp.

GC Electronics

Gibson-Homans Company

Glidden Company

Gulf Coast Paint Manufacturing, Inc.

Harco Chemical Coatings, Inc.

Hartin Paint & Filler Corp.

Hempel Coatings (USA), Inc.

Huntington Laboratories, Inc.

Hydrozo, Inc.

Imperial Paint Company, Inc.

Industrial Epoxy Coatings, Inc.

Iowa Paint Mfg. Co., Inc.

ITW Philadelphia Resins

James B. Day & Company

Jones Blair Company

Keeler & Long, Inc.

Klinger Paint Company, Inc.

Kool Seal, Inc.

Lilly Industries, Inc. -- Perfection Paint Division

Mameco International, Inc.

Maquet Paint/McGrevor Coatings

Matthews Paint Company

Minwax Company, Inc.

Multi-Clean Division of Hako Minuteman

National Polymers, Inc.

National Varnish Company

Okon, Inc.

Porter International (Division of Courtalds Coatings, USA)

PPG Architectural Finishes, Inc.

Pratt & Lambert, Inc.

Proko Industries, Inc.

Rainbow Coatings Corporation

Republic Powdered Metals, Inc.

Rich Art Color Co., Inc.

Robinson Chemical Coatings, Inc.

Rudd Company, Inc.

Rust-Oleum Corporation

Schulte Paint Manufacturing Company, Inc.

Seagrave Coatings Corporation of Virginia, Seaguard Division

Sheboygan Paint Company

Sherwin-Williams Company

Sigma Coatings

Somay Products, Inc.

Southwestern Petroleum Corporation

Standard T Chemical

Star Bronze Company, Inc.

Steelcote Manufacturing Company

Sunark - Narasco C/O MPV Company

Summyside Corporation

Tapecoat Company

Tenax Finishing Products Company

Texas Refinery Corporation

Thompson & Formby, Inc.

Thoro System Products

Themec Company, Inc.

Torginol, Inc. (Previously Peterson Chemical Corporation)

Tru-Test Manufacturing Company

United Gilsonite Laboratories

United Coatings, Inc.

United Paint Manufacturing Company, DBA United Coatings

Valspar Corporation (Consumer Division)

Valspar Corporation (Federal International Chem. Div.)

Valspar Corporation (Maintenance and Marine Division)

Valspar Corporation (McCloskey Division)

Vanex, Inc.

W.R. Grace & Co. - Conn

Waterlox Chemical & Coatings Corporation

Wellborn - De Corporation

Westinghouse - Electrical Materials Division

William Zinsser & Company, Inc.

Wiltech Corporation

Wood-Kote Products

Xim Products, Inc.

Zehrung Corporation

ZRC Products Company

DATA PROCESSING

Battelle Memorial Institute, under contract with the ARB, processed the survey data. As the surveys were received, the ARB did preliminary checks of the surveys and contacted by telephone all the respondents with obvious mistakes in their calculations, or obvious deficiencies or misunderstandings. ARB then discussed with Battelle how to electronically check the data using known relationships between the requested values. Battelle programmed these relationships into the computer and generated tables of line items that did not conform to these relationships. After further discussions, Battelle called the respondents to resolve the inconsistencies that could not otherwise be resolved. Most of the companies that responded to the survey were contacted either by ARB or by Battelle to resolve all of the data issues.

Several steps were taken to ensure the accuracy and completeness of the data:

- Data were keyed twice into separate Paradox data files by two different keyers. The resulting files were compared electronically and differences were resolved using the original data forms.
- Data were sorted and printed for visual inspection to identify missing data and obvious errors in completing the questionnaires.
- Electronic data checks were performed to identify problems with the data. These checks included verifying that (1) No critical data fields were missing (e.g., total sales, VOC content), (2) VOC range code agreed with reported VOC content, (3) VOC content of material agreed with VOC content at maximum thinning, and VOC regulatory (less water, less exempt) was greater than VOC content of material for all water-borne products, and (4) Certain relationships existed among reported VOC content parameters (material, maximum thinning, and regulatory) for all solvent-borne products.
- Most of the problems identified through visual inspection and electronic data checks were resolved by contacting company representatives. Approximately 85 companies were contacted by the ARB or Battelle. Most of the problems were easily resolved by correcting illegible data or recalculating values after discovering that the instructions were misunderstood.

The data presented in this report were provided to the ARB by participating companies who manufacture or distribute architectural and industrial maintenance coatings in California. In processing the data, Battelle made every effort to minimize errors in data entry and took several steps to identify inconsistencies in the data. Battelle and ARB attempted to resolve problems by contacting company representatives. The validity of the results presented in this report depends on the accuracy of the data which were provided by coating manufacturers and distributors.

RESULTS

SALES OF ARCHITECTURAL AND INDUSTRIAL MAINTENANCE COATINGS

Distribution of Sales by Company Size and Location

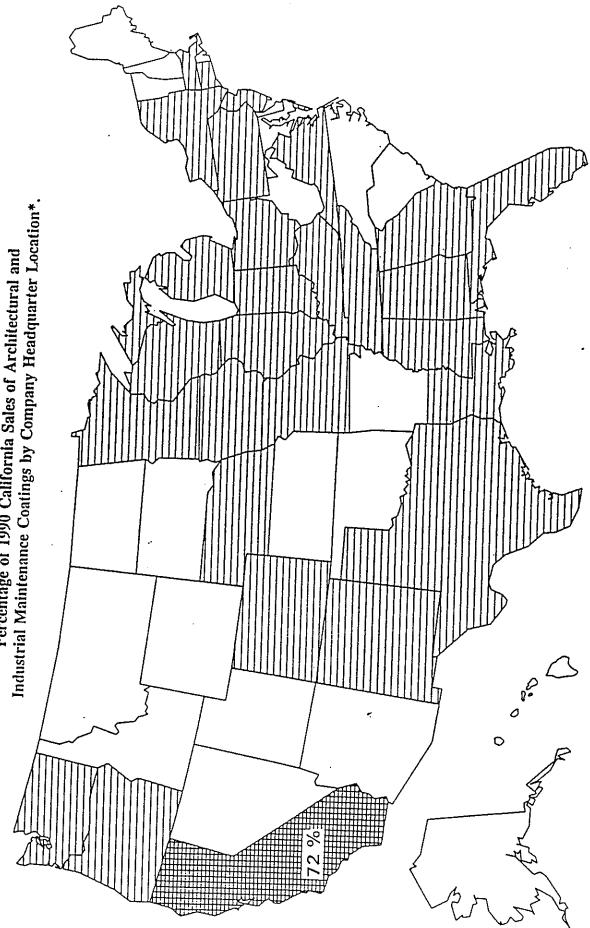
The 174 participating companies reported coating sales of 77.1 million gallons in California during 1990. Nearly three-quarters of the sales (72%) came from the 66 companies located in California. The remaining sales (28%) came from companies located in 27 other states, as shown in Figure 1.

Table 2 describes the distribution of companies by size, as determined by the annual business volume reported by the companies, and the contribution of these companies to the total coating sales in California. For example, 76 companies reported annual business volumes of less than \$5 million. Their total 1990 coating sales in California accounted for 6% of the total coating sales in the state. The 25 largest companies, reporting sales volumes of more than \$50 million, were responsible for more than half (57%) of the total coating sales in California. All companies with annual business volumes of less than \$10 million reported having fewer than 100 employees. All others had more than 100 employees.

Distribution of Sales by Coating Type and Carrier Technology

Table 3 lists the total reported coating sales of water-borne and solvent-borne products (including solvent-borne with exempts and 100% solids) in each of 33 coating categories. Tables 3, 4a, and 4b are similar to those published in the 1984 and 1988 survey results. The number of companies reporting sales in each category and the total number of products represented are also presented in Table 3. The survey questionnaire divided coatings into 39 categories. However, data on seven categories were combined into the category called "other specialty coatings" because these products are provided by fewer than four companies. Release of such data for individual categories could be considered proprietary by the manufacturers. The "other" category represents products that

Percentage of 1990 California Sales of Architectural and 1990 ARB AIM Coating Survey



*Shaded states other than California account for 28 percent of coatings sold in California. Figure 1

Table 2. Total AIM Coating Sales and Number of Companies Reporting Sales, by Size^(a) of Company

		Total AIM	Coating Sales
Company Sales Volume (\$M)	Number of Companies	Million Gallons	%
<5	76	4.9	(6%)
5-10	20	2.9	(4%)
10-50	53	25.1	(33%)
>50	25	44.1	(57%)
Total	174	77.0	(100%)

⁽a) Companies with sales volumes of less than \$10M have fewer than 100 employees. All others have more than 100 employees.

Table 3. Summary of 1990 California Sales of Architectural and Industrial Maintenance Coatings.

Anti-Grafifi Costing Anti-Grafifi Costing Anti-Grafifi Costing Below-Ground Wood Preservatives Clear Wood finishes - Lacquers Clear Wood finishes - Sanding Scalers Clear Wood finishes - Varnishes Clear Wood finishes - Varnishes Concrete Curing Compounds Clear Wood finishes - Varnishes Concrete Curing Compounds File Retardant Costing - Pigmented File Retardant Costing - File Compounds File Retardant Costing - File Corpus File Retardant Costing - File Corpus File Retardant Costing - File Costing - File File File File File File File File				-		l
We found whose Preservatives	Coating Category	No. of Companies	No. of Products	Water-based Coating Sales (1,000 Gal)	Solvent-based Costing Sales (1,000 Gal)	Total 1990 Costing Sales (1,000 Gal)
Specialty Coatings (1)	Anti-Graffiti Coating Below-Ground Wood Preservatives Clear Wood Finishes - Lacquers Clear Wood Finishes - Sanding Scalers Clear Wood Finishes - Varnishes Clear Wood Finishes - Varnishes Concrete Curing Compounds Dry Fog Coatings Fire Retardant Coating - Pigmented Fire Retardant Coating - Pigmented Form-Release Compounds Graphic Arts (sign) Ccatings High Temperature Coatings High Temperature Coatings High Temperature Coatings Wonflats - High Gloss Wonflats - High Gloss Wonflats - How Gloss Wonflats - Low Gloss Wonflats - Poly Enamels Opaque Stains Pre-treatment Wash Primers Primers Sealers and Undercoaters Roof Coatings Semi-transparent & Clear Wood Preservatives Sheming Pool Coatings Traffic Paints Waterproofing Sealers - Clear Waterproofing Sealers - Pigmented	227 4 8 227 4 8 23 4 4 7 1 1 6 6 4 7 2 2 2 2 2 2 3 4 8 8 8 8 8 1 1 6 8 9 2 2 2 2 2 3 8 8 8 9 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9	22 4 4 129 24 24 24 25 1, 105 1, 248 1, 248 4, 20 1, 248 4, 20 1, 248 4, 20 1, 248 4, 20 1, 248 4, 20 1, 248 4, 20 1, 20 2, 20	30 48 45 45 169 24 241 603 111 617 11,528 4 3,917 4 3,917 1,365 574 3,917 1,365 1,365 1,037 268		
174 6,996 58,796	Specialty Coatings (2)	36	113	19 31 317	55 88 156	1118
	ŀ	174	966'9	58,796	18,260	77,057

Other specialty coatings include bond breakers, clear fire retardant coatings, magnesite cement coatings, multi-color coatings, opaque wood preservatives, clear shellacs, and swimming pool repair coatings. Products not classified according to any of the ARB specified categories. E (2)

companies could not classify according to any of the general or specialty coating types.

Some of the information in Table 3 is highlighted in Figures 2a through 2c. Figure 2a, for example, shows that water-borne products account for over 75% of the total sales. Products containing exempt compounds and those reported to be 100% solids account for just over 5% of total sales. Figure 2b shows how the sales are distributed among two general categories (flats and non-flats) and selected specialty categories. The category of primers, sealers, and undercoaters with sales of 5.8 million gallons is the largest among the specialty coatings. Figure 2c gives a further breakdown of sales according to coating category and carrier technology. Notice that nearly all of the flat coatings are water-borne products while the majority of specialty coatings are solvent-borne. The lower bar graph in Figure 2c highlights the specialty coatings with the largest volume of sales.

1990 ARB AIM Coating Survey Distribution of AIM Coating Sales by Carrier Technology (Total Number of Gallons)

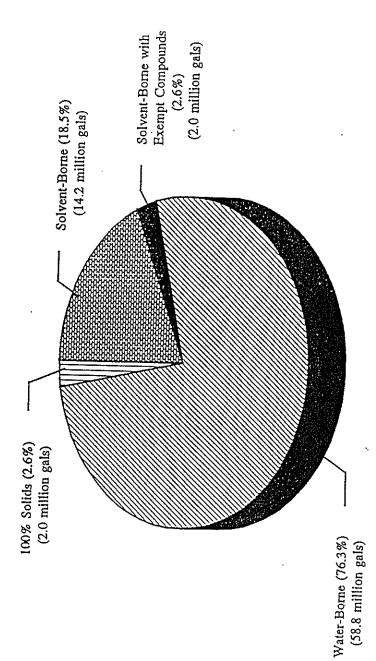
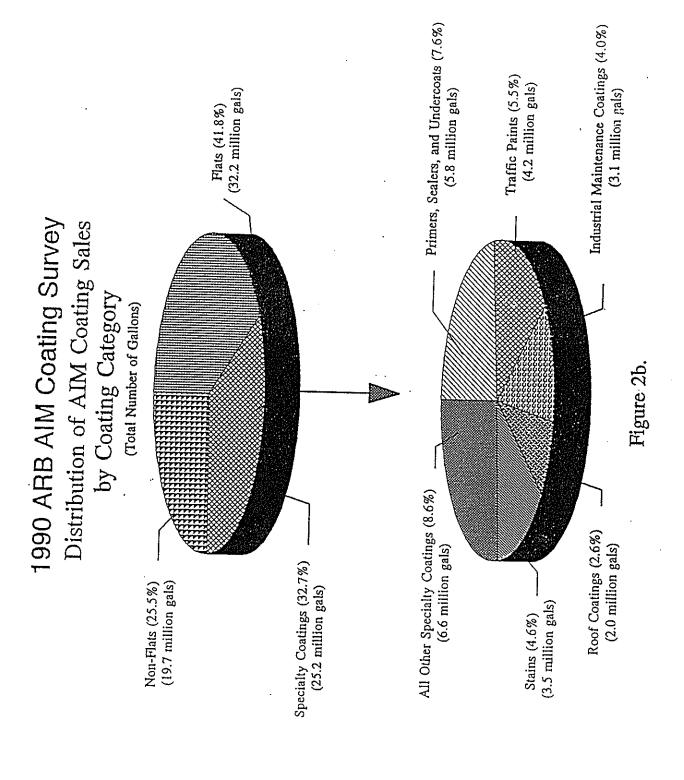


Figure 2a.



1990 ARB AIM Coating Survey

Total Sales (1,000 gals/year) of AIM Coatings by Coating Category and Carrier Technology

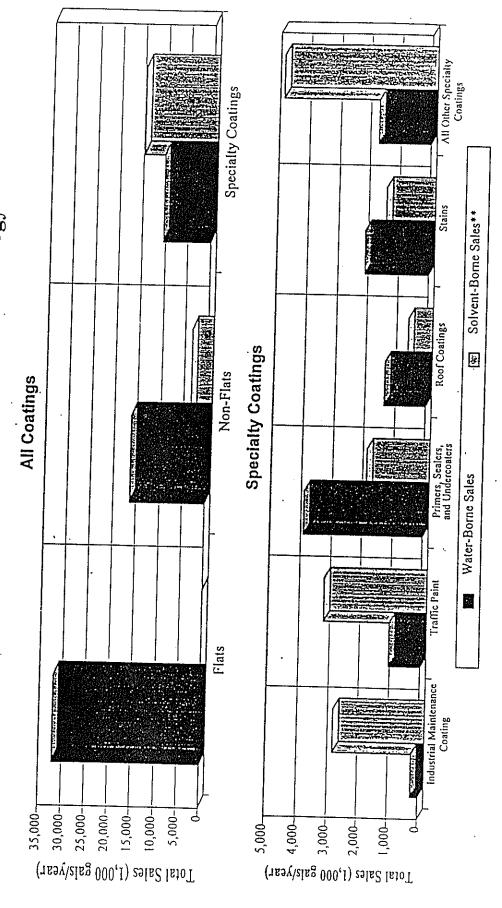


Figure 2c.

** Includes 100% solids and solvent-borne with exempts

ESTIMATED EMISSIONS FROM ARCHITECTURAL AND INDUSTRIAL MAINTENANCE COATINGS

The total VOC emissions from architectural and industrial maintenance coatings sold in California in 1990 is estimated to be 39,061 tons per year. This includes 12,880 tons of VOCs from water-borne coatings and 28,181 tons from solvent-borne coatings and the solvents used at manufacturer recommended thinning levels. It does not include emissions of VOCs from solvents that may be used in cleanup or for thinning beyond manufacturers' recommended levels.

Estimated Emissions from Water-Borne Coatings

Table 4a contains the estimated emissions from water-borne coatings in each category. Also presented are the sales weighted (SW) average volume percent solids (calculated as total volume of solids divided by total sales in each category), sales weighted average VOC content of the material (VOC_{mat} = grams of VOCs in the material per liter of material), and the sales weighted average regulatory VOC level (VOC_{reg} = grams of VOCs in the material per liter of material less water, less exempt solvents). Further definition of these parameters is provided in the instructions to the survey questionnaire contained in Appendix B.

Estimated emissions were calculated for each product by multiplying the reported material VOC content (g/l) by the reported volume of material sold (gallons/year), then multiplying by the appropriate factor to convert results to tons per year. Total emissions from water-borne coatings are estimated to be 12,880 tons/yr. Almost 83% of these emissions are from flat and non-flat water-borne products, which account for 82% of the total water-borne product sales.

Estimated Emissions from Solvent-Borne Coatings

The estimated emissions from solvent-borne coatings are shown for each coating category in Table 4b along with sales weighted averages of percent solids, material

Table 4a. Estimated Emissions from 1990 California Sales of Architectural and Industrial Maintenance Coatings. 1990 ARB AIM Coating Survey WATER-BORNE COATINGS

Coating Category	Total 1990 Coating Sales	SW Avg. Percent	SW Avg. Material VOC (1)	SW Avg. Regulatory Voc (2)	Estimated
\$ 1000 miles	(1,000 gal.)	Solids	(1/b)	(3/1)	(tons/yr)
Anti-Graffiti Coating	30	51.9	6 44	4 724 4	
Liear Wood Finishes - Lacquers	48	28.5	123.5	2.62	20
Liear Wood Finishes - Sanding Sealers	6	22.6	67.3	202.	8
Liear Wood Finishes - Varnishes	57	2 80	2.6	6,52,6	~
Concrete Curing Compounds	140	1.02	2.5.5	205.6	- 15
Dry Fog Coatings	2 %	23.2	5.5	118.3	80
Fire Retardant Coating - Pigmented	5 ^	 	50.2	75.6	5
Flats	311 02	4.0.4 0.0	- ·	26.0	0
Form-Release Compounds	2 7	, c	44.1	104.7	5,889
Graphic Arts (sign) Coatings	* u	7.7	49.3	592.4	-
Industrial Maintenance Coatings	2,7	40.6	44.3	97.3	-
Mastic Texture Coatings	707	4.00	7. 96	205.9	26
Metallic Pigmented Coatings	G :	50.1	2 55	87.6	112
Nonflats - High Gloss	- 6	ر د ا	6.0	18.0	0
Nonflats - Medium Gloss	100	39.3	98.2	211.4	281
Nonflats - Low Gloss	2,043	36.9	70.3	162.3	3,699
Nonflats - Quick Dry Enamels	70,47	57.1	63.6	153.5	785
Opaque Stains	- 60	33.8	43.9	106.9	-
Pre-treatment Wash Primers	0761	56.1	54.3	133.0	345
Primers Sealers and Undercoaters	2 0 5	- - - -	293.0	702.0	5
Quick Dry Primers, Sealers & Undercoaters	2,7	7.1	2.44	116.8	729
Roof Coatings	1 245	20.0	45.2	9.96	16
Semi-transparent Stains	200,1	4.44	36.2	67.2	506
Semi-transparent & Clear Unod Preservatives	÷ ;	0.5	72.9	257.8	174
Traffic Paints	35	7.5	6.24	279.6	• • •
Waterproofing Sealers - Clear	150,1	7.0	78.3	120.5	338
Waterproofing Sealers - Pigmented	9 5	· ·	20.0	158.2	22
Other Specialty Coatings (3)	<u> </u>	7.0.	28.9	58.3	~
Other (4)	747	2.92	317.7	560.4	₩ 1
		7.4.	42.5	88.1	26
All coating types pooled	58,796	38.2	52.7	124.3	12 ABO
			_		-

Sales weighted average grams of volatile organic compounds (VOC) per liter of material. Sales weighted average grams of volatile organic compounds (VOC) per liter of material plus thinning solvent less water less €8

"Other specialty coatings" include bond breakers, clear fire retardant coatings, magnesite cement coatings, multi-color coatings, opaque wood preservatives, clear shellacs, and swimming pool repair coatings.

Products not classified according to any of the ARB specified categories. 9

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Table 4b. Estimated Emissions from 1990 California Sales of Architectural and Industrial Maintenance Coatings.

Solvent-Borne Coatings

		- [L									
	Coating Category	Total 1990 Coating Sale (1,000 Gal)	SW Avg Percent Solids	SW Avg(1) Material VOC(g/l)	SW Avg VOC(2) at Max Thinning VOC (g/l)	SH Avg(3) Regulatory VOC (g/l)	SV Avg. Recomm.	From fr	Estimated VOC Emissions from Recomm.		(tons/year) Total	
*****							2	הפוכו ומן	Ininning	Total	Max Thin.	
	Below-Ground Wood Preservatives	622	81.3	161	161	173	00.00	,	•			
	Clear Wood Finishes · Lacquers	845	26.0	225	377	377	0.00	0 0	00	9	9	
-	Clear Wood Finishes - Sanding Sealers Clear Wood Finishes - Varnishes	378	22.9	299	668	868	0.93	2,341	29.0	58 7 270	58	
	Concrete Curing Compounds	816	44.2	432	436	434	9.0	1,048	0	1,048	1,055	
	Dry Fog Coatings	3.5	0.67	7.5	764	794	00.0	794,1	0	1,467	1,501	
	Fire Retardant Coating - Pigmented	16	53.0	373	37.5	392	0.00	125	<u> </u>	94	76	
•	form-Release Compounds	61	47.0	347	359	265	0.00	52	0	32	92	
	Graphic Arts (sign) Coatings	865	21.7	597	297	597		88		88	536	
	High Semperature Coatings	13	36.6	7 0 2 2	428	412	0.22	700	0 \	5:5	.5	
	Mastic Tather Catings	2,837	56.5	295	000	539	0.00	30	J C	908	677	
	Metallic Pigmented Costions	172	58.3	186	276	374	1.12	4,301	117	30	333	
	Nonflats - High Gloss	355	52.9	470	725	1027 1027	96.5	133	76	722	4,859	
1	Nonflats - Hedium Gloss	1,530	61.2	313	318	348	2.0	769	0	769	207	
0	Honflats - Loy Gloss	70	- N	282	283	298	200	1,734	27	1,762	1,798	
	Nonflats - Quick Dry Enamels	483	55.5	702	293	384	2.71	147	20	738	1,746	
	Pre-freshment Link Daimer	258	50.9	394	507	707	0.00	808	· C	0 0	165	
	Primers Sealers and Independent	13	8.4	729	73,	252	9.0	425	0	267	810	
	Quick Dry Primers Sealens & Hodensonton	1,8/1	24.4	322	331	271	3.07	53	2	1 10	0 7	
	Roof Coatings	782	46.3	369	386	418	770	2,504	84	2,588	2,700	
	Semi-transparent Stains	1.163	1.07	263	263	263	8	438	41	625	483	
	Semi-transparent&Clear Wood Preservatives	231	50.5	7.77	175	432	00.0	2 032	> c	729	7.29	
	Suiming Dool Continued	7.2	33.6	2,00	700	367	0.00	353	5 C	2,05/	2,038	_
	Traffic Paints	m	31.4	572	575	777	6.14	162	17	170	555	
	Haterproofing Sealers - Clear	3,200	78.9	117	118	132	9.0	eo i	0	φ	<u> </u>	
	Waterproofing Sealers - Pigmented		7.07	410	410	418	000	1,563	0	1,563	1,565	
_	Other Specialty Coatings (4)		30.4	5,57	399	366	0.00	200	5 6	1,162	1,162	_
	orner (5)		47.5	7.00	797	588	0.0	208	00	206	92	
_	All coating types pooled	╀	11.0			2/1	U.3U	325	2	324	325	
J		10, 200	٥٠,٠٥	539	347	355	99.0	25,737	777	24 501	0,0	
<u>_</u>	Sales weighted average accompany to		٠							101,03	750,12	

Sales weighted average grams of volatile organic compounds (VOC) per liter of material.
Sales weighted average grams of volatile organic compounds (VOC) in material plus solvents at maximum thinning per liter of material plus solvent.
Sales weighted average grams of volatile organic compounds (VOC) per liter of material plus thinning solvent less water less exempt compounds.
"Other specialty coatings" include bond breakers, clear fire retardant coatings, magnesite cement coatings, multi-color coatings, opaque wood preservatives, clear Products not classified according to any of the ARB specified categories. (2)

5885

VOC content, VOC content at maximum thinning (VOC_{MT}), and regulatory VOC content. The VOC content at maximum thinning is the total weight (grams) of VOCs in the material plus thinning solvent at maximum thinning levels divided by the total volume (liters) of material plus thinning solvent. The estimated total annual emissions from solvent-borne coatings, including emissions from the material and solvents used at recommended thinning, is 26,181 tons. The largest source of emission among the various coating categories is the category of industrial maintenance coatings. This category contributes nearly 17% of the total emissions from all solvent-borne coatings.

According to the ARB-CAPCOA Suggested Control Measure (May 12, 1989) VOC_{reg} for solvent-borne coatings is to be calculated based on the VOC content of the material plus recommended thinning solvent. That is, VOC_{reg} equals the total weight (grams) of VOCs in the material plus recommended thinning solvent divided by the total volume (liters) of material plus solvent.

The survey did ask for VOC content at recommended thinning; however, it did not ask specifically for the amount of solvent used to thin the coating. To estimate the emissions due to thinning, we considered the relationship between VOC_{mat}, VOC_{MT}, and VOC_{reg} for solvent-borne products. These values depend on the manufacturer's recommendation for thinning and whether or not the product contains exempt compounds. This information was used to estimate the level of recommended thinning. Table 4b contains the sales weighted average level of recommended thinning (total volume of solvent for recommended thinning as a percent of total sales) in each category. For example, the average recommended thinning of mastic texture coatings is nearly 15%. On the other hand, thinning is not recommended for most products. The average level of thinning recommended for solvent-borne coatings is less than one percent.

The level of recommended thinning could not be determined for the 11% of solvent-borne sales that contain exempt compounds. For some individual products containing exempt compounds, the value reported for VOC_{MT} was less than the value reported for VOC_{reg} . This is reflected in the relationship between the corresponding sales-weighted averages in Table 4b ($VOC^{(2)} < VOC^{(3)}$) for some of the coating categories. However, for the vast majority of products that do not contain exempts, companies either reported $VOC_{mat} = VOC_{reg} \le VOC_{MT}$, implying that thinning is not recommended, or $VOC_{mat} < VOC_{MT} = VOC_{reg} \le VOC_{MT}$, implying that thinning is not recommended, or $VOC_{mat} < VOC_{MT} = VOC_{mat} =$

 VOC_{reg} , implying that thinning is recommended at the maximum thinning level. Therefore, using the definition of VOC_{mat} and VOC_{MT} and the U.S. EPA estimate of 883 g/l for the average density of VOCs, it can be shown that the volume of recommended thinning solvents is

$$V_{s,rec} = V_{mat}(VOC_{reg} - VOC_{mat})/(883 - VOC_{reg}),$$

where V_{mat} is the volume of material sold. (Note: The volume of thinning solvents equals zero if $VOC_{reg} = VOC_{mat}$. Adjustments were made for the few cases involving products with exempt compounds that require thinning.)

The volume of solvents used at maximum thinning was also calculated to determine the maximum estimated emissions if all products were thinned at the maximum level. The formula for the volume of thinning solvents at maximum thinning is

$$V_{s,MT} = V_{mat}(VOC_{MT} - VOC_{mat})/(883 - VOC_{MT}).$$

Notice that $V_{s,MT} = V_{s,rec}$ if the company reported $VOC_{MT} = VOC_{reg}$.

Total estimated emissions are divided into two parts in Table 4b: Emissions from the material, and emissions from the solvent used at recommended thinning. Estimated emissions from the material were calculated by

Material Emissions =
$$VOC_{mat} \times V_{mat}$$
.

Total emissions, including material emissions and emissions from recommended thinning solvents, were calculated by

Total Emissions =
$$VOC_{reg} \times (V_{mat} + V_{s,rec})$$
.

Estimated emissions from recommended thinning solvents were obtained by subtracting material emissions from total emissions.

The final column in Table 4b contains the estimated total emissions at maximum thinning. This was calculated by

Total Emissions at Maximum Thinning = $VOC_{MT} \times (V_{mat} + V_{s,MT})$.

This value is only presented as a reference value. It represents an upper bound on emissions if all consumers used each product at its maximum recommended thinning.

The estimated emissions in Table 4b do not include emissions due to cleanup. In reporting the total estimated emissions from solvent-borne coatings based on surveys conducted in 1984 and 1988, the ARB calculated the emission from thinning and cleanup by assuming that one pint of VOC thinner having a density of 770 grams per liter was used per gallon of solvent-borne coating (excluding roof coatings). In 1988, ARB estimated thinning and cleanup emissions to be 5,966 tons per year based on a solvent-borne coating sales of 17.4 million gallons. The same method would produce a similar estimate of thinning and cleanup emissions for the 18.3 million gallons of solvent-borne coating sold in 1990. Comparisons among the different surveys are presented later in the report.

Distribution of Emissions by Carrier Technology and Coating Category

Figures 3a through 3c show the distribution of estimated emissions among the different carrier technologies and coating categories. These figures have the same format as Figures 2a through 2c except they describe the distribution of emissions rather than sales. Notice in Figure 3a that water-borne coatings, which comprise nearly 76% of the total sales (See Figure 2a.), account for less than one-third of total emissions. Solvent-borne coatings with exempt compounds account for about 4% of the total emissions. A few coatings were classified by manufacturers as 100% solids but contained small amounts of VOCs (less than 5% by volume).

Figure 3b shows that the specialty coatings account for more than half of the estimated total emissions. Furthermore, as shown in the lower pie chart, no one category of specialty coatings contributes more than 15% to the total. A further breakdown is provided in Figure 3c. The specialty coatings which produce the largest amount of emissions are highlighted in the lower bar graph.

1990 ARB AIM Coating Survey Distribution of AIM Coating Emissions* by the Carrier Technology (Total Number of Tons)

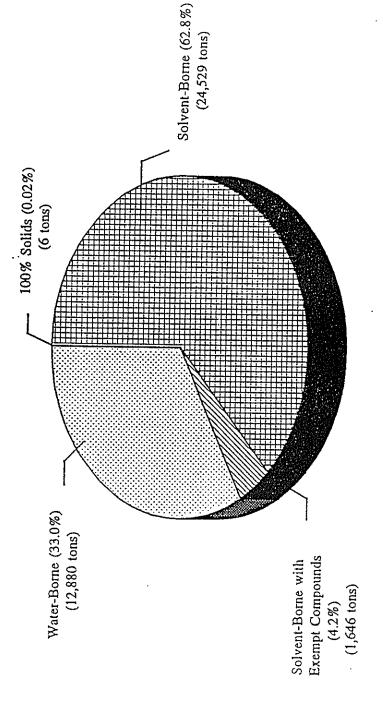
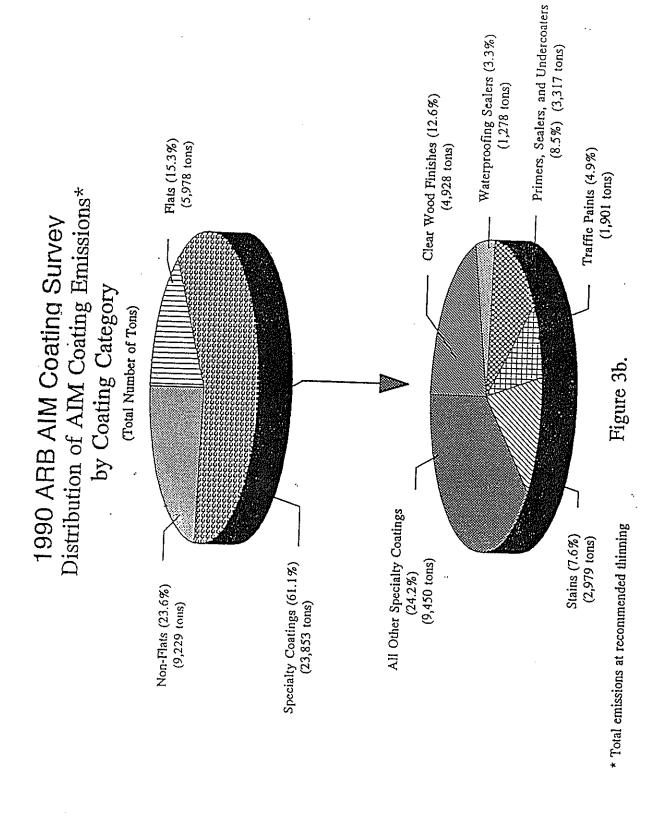
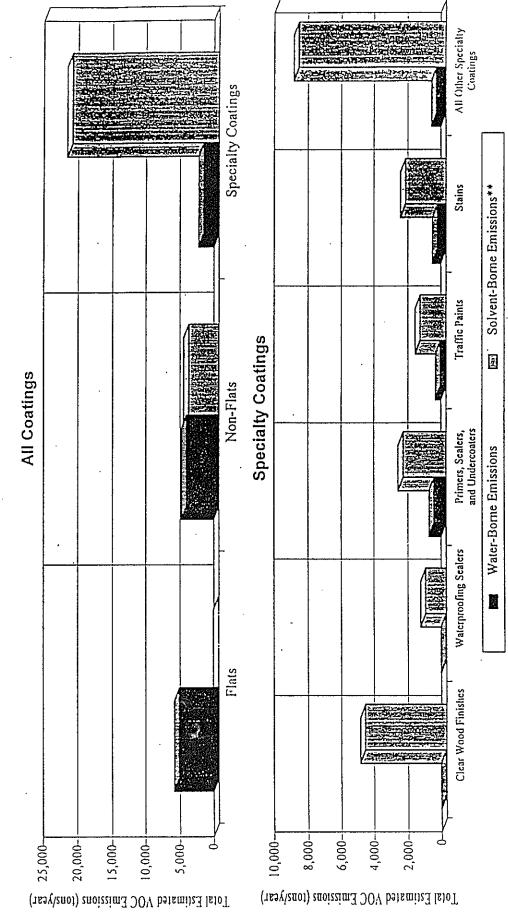


Figure 3a.

* Total emissions at recommended thinning



Total Estimated VOC Emissions* (tons/year) of AIM Coatings by Coating Category and Carrier Technology



* Total emissions at recommended thinning

** Includes 100% solids and solvent-borne with exempts

POTENTIAL EMISSION REDUCTIONS DUE TO 1989 ARB-CAPCOA SUGGESTED CONTROL MEASURE 1992 LIMITS

Tables 5a and 5b show the potential emission reductions by coating category for water-borne and solvent-borne coatings that might be achieved by the 1989 ARB-CAPCOA Suggested Control Measure 1992 standards relative to the 1990 emissions estimates. Potential emission reductions were calculated under two different assumptions: (1) The total volume of solids will remain constant (Method A — the EPA method), and (2) The total volume of material sold plus the volume of solvents used at recommended thinning will remain constant (Method B). These calculations are discussed in a separate section below.

The two methods produced fairly similar estimates of total emission reduction for the water-borne coatings — 79 and 71 tons per year. However, the estimated emission reduction in individual categories were not always the same. For example, Method A estimated emissions reduction of 28 tons per year for the low gloss non-flat coatings. Method B estimated the emissions reduction to be 8 tons per year from this category. Both methods agree that most of the potential emission reductions would occur in the low gloss non-flat and semi-transparent stain categories, as well as the group of specialty coatings sold by fewer than four companies.

Not surprisingly, the Suggested Control Measure would have the largest impact on solvent-borne coatings. As shown in Table 5b, Method A estimates the potential total emission reductions from solvent-borne coatings to be 7,887 tons per year. The largest source of reductions would be from industrial maintenance coatings. Method B estimates the potential reduction to be 4,841 tons per year with sanding sealers contributing the largest share.

The rule limits listed in Tables 5a and 5b under the "Other Specialty Coatings" represent sales weighted averages of the limits for the pooled categories.

Potential Emission Reduction Due to 1989 Suggested Control Measure 1992 Limits, Based on Survey of 1990 Sales. Table 5a.

Water-Borne Coatings

Potential Emission Reduction(3) Hethod A Hethod B	Tons/yea	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.000	1 (98.3)	(0.0)	(2.1.2)	0.00	1 (0.4)	0.000	0 0 0 0	0 (0.0)	4 (77.2)	0.00	-	33 (19.2)	<u> </u>		0.000	1 (2.4)	71 (0.5)
Potential Emis Hethod A	Tons/year (%)	0.00	0.00	3 (17.4)	0.0.0	0.00	1 (84.5)	3 (0.0)	0 0 0 0	0 (0.0)	2 (0.8)	_	0 (1.9)	0.000	4 (77.2)	1 (3.7)	0 (0.1)	0 (5.5)	0000		0 (0.0)	2(3.9)	79 (0.6)
Estimated 1990 VOC Emissions	(tons/yr)	23. ₈₈	iw f	<u> </u>		5,889		- 26	112	0 50	3 609	785	0	245	720	16	206	7,	338	2 <u>5</u>	41	56	12,880
SW Avg.(2) 1992 VOC Rule Limit	(3/5)	340 680	350	350	400	250	250	340	300	200	320	250	250	280	350	350	300	320	250	400	418 (5)	250	564
SW Avg.(1) Regulatory VOCCO(1)	(2/6)	302	294	118	9. 26.	105	292 292	206	න ද	211	162	153	132	702	117	97	258	280	121	ŭ ru	550	88	124
Total 1990 Coating Sales (1,000,6al)	20	48	, ,	169	47	32,116	t in	241	903	789	12,645	796'7	1,528	7	3,917	345 4	574	25	1,037	6			58,796
Coating Category	Anti-Graffiti Coating	Clear Wood Finishes - Lacquers Clear Wood Finishes - Sanding Seators	Clear Wood Finishes - Varnishes	Ory Fog Coatings	Fire Retardant Coating - Pigmented	Form-Release Compounds	Graphic Arts (sign) Coatings	Hastic Texture Coatings	Metallic Pigmented Coatings	Nonflats - High Gloss	Nonflats - Low Gloss	Nonflats - Quick Ory Enamels	Opaque Stains	oriment Yash Primers		Roof Coatings	Semi-transparent Stains	Traffic Paints	Waterproofing Sealers - Clear	Waterproofing Sealers - Pigmented	Other (6)		these pooled

Sales weighted average grams of volatile organic compounds (VOC) per liter of material plus thinning solvent less water less exempt compounds.
ARB-CAPCOA suggested control measure (Hay 12, 1989).
Hethod A: Constant total volume of solids. Hethod B: Constant total volume of material.
Other specialty coatings include bond breakers, multi-color coatings, and opaque wood preservatives.
Sales weighted average of rule limit values over three coating categories.
Products not classified according to any of the ARB specified categories.

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Potential Emission Reduction Due to 1989 Suggested Control Measure 1992 Limits, Based on Survey of 1990 Sales. Table 5b.

Solvent-Borne Coatings

ion Reduction Thinning (3 Hethod B	1005/year (2) 10 (0.3) 12 (21.2) 13 (70.2) 14 (46.5) 26 (20.6) 27 (25.4) 28 (89.8) 26 (20.6) 27 (10.6) 28 (10.6) 28 (10.6) 29 (10.6) 29 (10.6) 20 (11.6) 20 (11.6) 20 (11.6) 20 (11.6) 20 (11.6) 20 (11.6) 20 (10.9)	4,841 (18.5)
Potential Emissi at Recommended Method A	1	7,887 (30.1)
Estimated 1990 VOC Emissions (tons/yr)	2,370 1,048 1,467 1,762 1,738 1,738 1,738 1,738 1,738 1,738 1,762 1,738 1,762 1,762 1,762 1,762 1,762 1,762 1,762 1,763 1,762 1,763	26, 181
SW Avg. 1992 VOC(2) Rule Limit (9/L)	340 340 340 340 340 340 340 340 340 340	. 336
SW Avg.(1) Regulatory VOC (g/L)	173 173 173 173 173 173 174 175 175 175 175 175 175 175 175 175 175	355
Total 1990 Coating Sales (1,000 Gal)	2,285 2,837 2,837 1,730 1,730 1,631 2,231 2,231 2,231 1,633	10, 200
Coating Category	Anti-Graffiti Conting Below-Ground Wood Preservatives Clear Wood Finishes - Lacquers Clear Wood Finishes - Sandings Clear Wood Finishes - Sandings Concrete Curing Compounds Dry Fog Coatings Fire Retardant Coating - Pigmented Flats Form-Release Compounds Graphic Arts (sign), Coatings High Temperature Coatings High Temperature Coatings High Temperature Coatings Hodusfrial Haintenance Coatings Honflats - Hedium Gloss Wonflats - Hedium Gloss Wonflats - Hedium Gloss Wonflats - Low Gloss Wonflats - Pigmented Spains Fretreatment Wash Primers Semi-transparent Stains Semi-transparent & Clear Wood Preservatives Shellecs - Pigmented Symming Pool Coatings Traffic Paints Waterproofing Sealers - Figmented Other Specialty Coatings (4) Other Specialty Coatings (4) Other Specialty Coatings types pooled	

Sales weighted average grams of volatile organic compounds (VOC) per liter of material plus thinning solvent less water less exempt compounds. ARB-CAPCOA suggested control measure (May 12, 1989).
Hethod A: Constant total volume of solids. Method B: Constant total volume of material plus recommended thinning solvents.
Other specialty coatings include bond breakers, clear fire retardant coatings, magnesite cement coatings, multi-color coatings, opaque wood Sales weighted average of rule limit values over seven coating categories.
Products not classified according to any of the ARB specified categories.

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Calculation of Potential Emission Reduction

It can be shown that the VOC emissions from a product that exactly meets a regulated limit $VOC_{reg} = L$ is given by

Regulated Emissions =
$$L/(1-L/883)xBxV_{mat}$$
,

where β is the volume percent solids of the material.

Because the regulated VOC limit (VOC_{reg}) depends only on the amount of VOCs per volume of solids sold (volume of solids = $\beta x V_{mat}$), no further assumptions were needed using Method A to calculate potential emission reductions. However, to calculate emission reductions under the assumption of constant volume of material plus thinning solvents, Method B, some assumptions were required. If thinning is not currently recommended, then it was assumed that thinning would not be recommended under a new formulation and the volume percent of solids for the new product would be equal to the average percent solids for all products that currently meet the new limit. Data provided by the manufacturers indicated that the solids content of products that currently meet the new limits were generally 20% higher than products that failed to meet the standard. If thinning is recommended by the manufacturer, the following formula was used:

Regulated emissions =
$$Lx(V_{mat} + V_{s,rec})$$
.

Potential emission reduction was then calculated by summing the positive differences between estimated emissions and regulated emissions for all products within each coating category.

COATING SALES AND EMISSIONS BY TYPE OF RESINS USED

Figure 4a shows the volume of AIM coatings that contain various resins. For example, acrylics were the only resin reported for approximately 36 million gallons of coatings sold in 1990. Acrylics were used in combination with other resins in another 4 million gallons of coatings. Alkyds and vinyls were the only other resins used in categories

with at least 10 million gallons of coating sales. Figure 4b reveals that acrylics and vinyls are used primarily in water-borne coatings, while alkyds are the primary resins used in solvent-borne coatings.

Emissions from products that use various resins are shown in Figures 5a and 5b. Emissions from water-borne coatings that use acrylics and vinyls are generally proportional to sales. However, the relative emissions from solvent-borne products that use cellulosic resins are somewhat higher than those from other products. Cellulosic resins are primarily used in clear wood lacquers and sanding finishes.

1990 ARB AIM Coating Survey Total 1990 Sales (1,000 gallons/year) of AIM Coatings

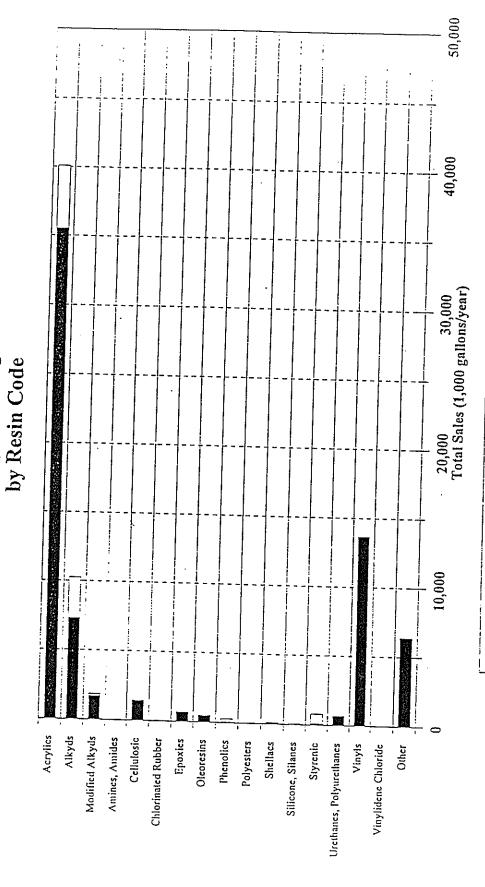


Figure 4a.

In Combination with Other Resins

Alone

1990 ARB AIM Coating Survey

by Carrier Technology (Solvent-Borne or Water-Borne) and Resin Code Total 1990 Sales (1,000 gallons/year) of AIM Coatings

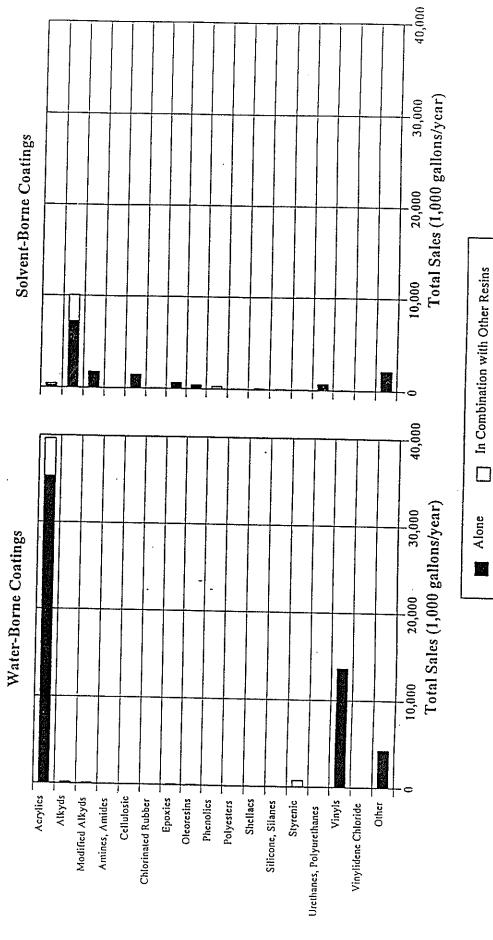
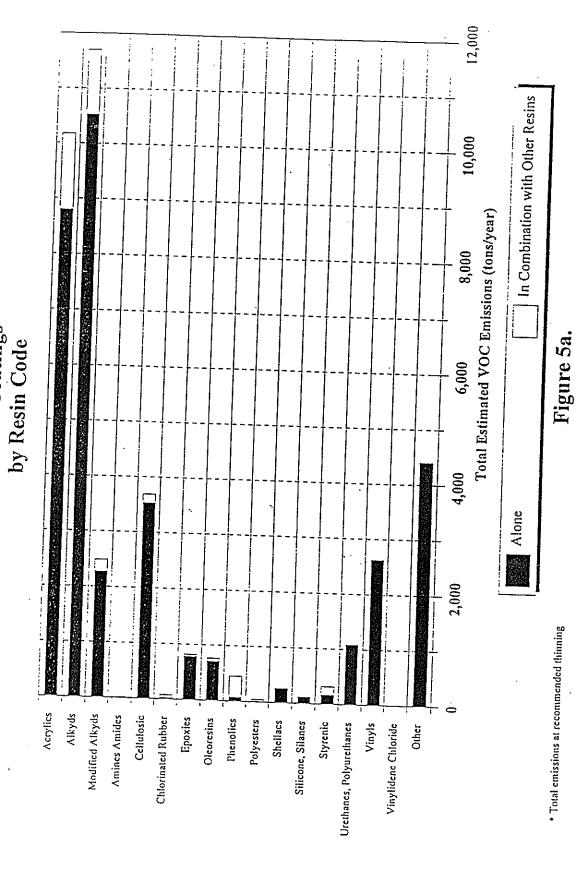
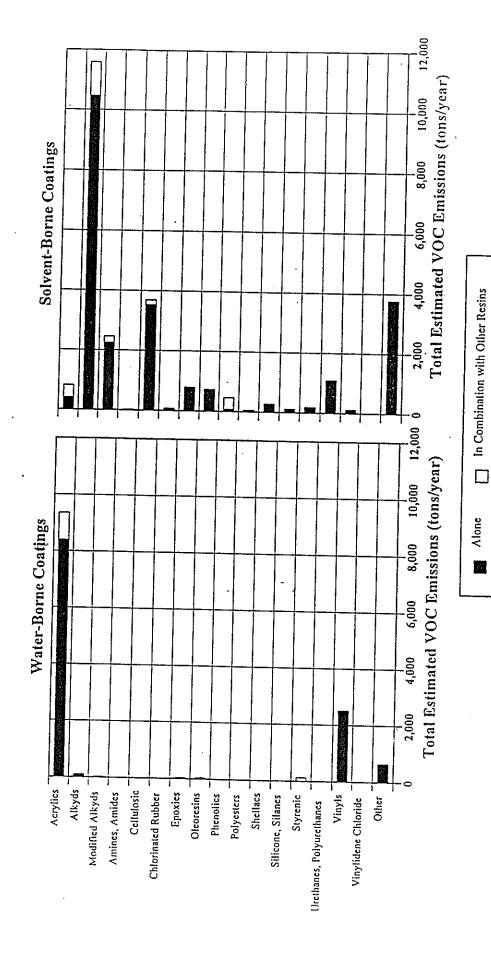


Figure 4b.

1990 ARB AIM Coating Survey
Total 1990 Estimated VOC Emissions* (tons/year)
of AIM Coatings



by Carrier Technology (Solvent-Borne or Water-Borne) and Resin Code Total 1990 Estimated VOC Emissions* (tons/year) of AIM Coatings



* Total emissions at recommended thinning

Figure 5b.

COMPARISON OF RESULTS WITH PRIOR AIM COATING SURVEYS

Four architectural coatings surveys have been conducted by the ARB since 1980. They were based on sales in 1980, 1984, 1988, and 1990. For the 1984 survey 143 manufacturers responded, and in 1988 the survey had 120 respondent companies. For the current survey, based on 1990 sales, a total of 174 companies responded. About 60 percent of the 130 companies queried for the 1988 survey were not respondents to the 1984 survey. Sixty-four percent of the respondents in 1984 were not among the respondents in 1988. Of the 174 manufacturers that responded to the 1990 survey 53 percent were companies that had not responded to either the 1984 or 1988 surveys. Omission of a company on the list from one survey to the next may be the result of the company no longer doing business in California, a change in the company name, the company going out of business, the company merging with another company, or the company not responding to the survey.

The product categories varied with each survey. The surveys have become more refined through the years and therefore the definition of the coating products has been changed in each survey. In 1980 there were 27 categories. In 1984 the survey divided the products into 29 categories, then in 1988 it was 38 categories, and in 1990, 41 categories were used. These increases have not resulted from simply increasing the number of subdivisions. For some surveys there were consolidations of categories from the previous survey while new categories were added. For instance, in 1990, quick-dry primers, sealers, and undercoaters were combined into one group, as were general primers, sealers, and undercoaters. At the same time the 1988 non-flat coatings category was split out into the high gloss, medium gloss, low gloss, and quick-dry enamel subcategories.

Total California sales of all architectural coatings (including both solvent-borne and water-borne) as reported by the manufacturers are shown in Table 6.

According to survey results, California sales of all architectural coatings reached a peak in 1988 and decreased from then to 1990. Sales and estimated VOC emissions from solvent-borne coatings were highest in 1984, while the year of highest sales and emissions from water-borne coatings was 1988. Note that the sales weighted average material VOC contents for water-borne coatings, solvent-borne coatings, and all coatings combined have consistently decreased between 1984 and 1990. Table 6 was compiled from

Table 6. Comparison of Results of the Air Resources Board's Architectural Coatings Surveys in 1980, 1984, 1988, and 1990

Year	Total Sales (1,000 gallons)	Sales Weighted Average of Material VOC Content (g/l)	Estimated VOC Emission from Material (tons/year)	Estimated VOC Emissions at Recommended Thinning (tons/year)
Solvent-bo	rne Coatings			
1980 1984 1988 1990	15,141 21,028 17,376 18,260	(a) 451 379 339	28,464 39,549 27,421 25,737	33,417 ^(b) 46,957 ^(b) 33,387 ^(b) 26,181 ^(b)
Water-bor	ne Coatings		1	
1980 1984 1988 1990	26,471 37,453 60,500 58,796	_(a) 60 58 53	6,017 9,310 14,641 12,880	6,017 ^(c) 9,310 ^(c) 14,641 ^(c) 12,880 ^(c)
Totals for	All Coatings			
1980 1984 1988 1990	41,612 58,481 77,815 77,057	 200 130 121	34,481 48,859 42,062 38,617	39,434 56,267 48,028 39,061

⁽a) Not calculated in 1980.

Sales
$$\frac{\text{(gal.)}}{\text{year}} \times 1/8$$
 (solvent gal./sales gal.) x 6.4 lb/gal. x $\frac{1}{2000 \text{ lb/ton}}$

No thinner is used for roof coatings. For 1990 the recommended thinning volume was calculated from reported VOC levels.

(c) No thinner is used with water-borne architectural coatings.

⁽b) In 1980, 1984 and 1988 maximum thinning of solvent-borne coatings (except roof coatings) was assumed to be attained by adding one pint of thinner to each gallon of coating. The calculation is:

the data given in Table 2 of "Results of 1984 Architectural Coating Sales Survey" (California Air Resources Board, July 1986) and Tables 2 and 3 of "Results of the 1988 Architectural Survey" (California Air Resources Board, May 1991).

Comparisons of the sales and estimated emissions from the different coating categories show that there was not a uniform decrease in emissions over all the categories between 1988 and 1990. Nor is there any consistent pattern of increases in sales of water-borne coatings accompanying decreases in sales of solvent-borne coatings. The overall decrease in sales and emissions noted for all water-borne coatings, all solvent-borne coatings, and all architectural coatings combined is a result of large decreases in sales and emissions in some categories, such as lacquers, flats, and roof coatings, outweighing smaller increases in sales and emissions in other categories, such as graphic arts, traffic paints, and concrete curing compounds.

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APPENDIX A

1989 ARB-CAPCOA SUGGESTED CONTROL MEASURE FOR ARCHITECTURAL COATINGS

	•			

AIR RESOURCES BOARD 1102 Q STREET F.O. 80X 2815 SACRAMENTO. CA 95812



July 7, 1989

Air Pollution Control Officers:

ARB-CAPCOA Suggested Control Measure for Architectural Coatings

On May 12, 1989, the Air Resources Board (Board) approved, with amendments, a suggested control measure (SCM) for architectural coatings. The SCM was developed by the Air Resources Board-CAPCOA Technical Review Group (TRG). On May 24, the TRG approved the amended SCM, making it the "ARB-CAPCOA Suggested Control Measure for Architectural Coatings." The TRG is now recommending the SCM to districts for adoption into their regulations.

The SCM is being sent to you for your use in adopting regulations needed for attainment or maintenance of state and federal ambient air quality standards. Adoption of a regulation based on this SCM or amendment of an existing architectural coatings regulation to be consistent with the SCM is appropriate if emission reductions from the use of architectural coatings are needed in your district.

During the development of this SCM, a major concern shared by the TRG and the coatings industry was the uniformity of architectural coatings regulations in California. Non-uniformity among the districts' architectural coatings regulations has created difficulties for both the air pollution control community and the paint industry. In its resolution approving the SCM, the uniformity among the districts' architectural coatings rules. To this end, I believe it is important in adopting this SCM as your architectural coatings rule, that you make only those changes absolutely necessary to fit the SCM into the structure of your definitions, the standards, and the effective dates be uniform.

Attached is a copy of the "ARB-CAPCOA Suggested Control Measure for Architectural Coatings" (Attachment A). The staff report supporting the SCM, including a draft version of the suggested control measure, and public notice of the Air Resources Board's meeting to consider the SCM were mailed to you on April May 1.

As approved, the suggested control measure is different from the draft version mailed on April 24. The differences reflect changes made by the TRG prior to the Board's meeting on May 12, and changes made by the Board at that meeting. Because of those changes, some of the information in the supporting documentation is now obsolete. Attached is new material to replace such obsolete information (Attachment B), including a table of recalculated emission reductions (Table 6). Also attached is the letter from the TRG endorsing the SCM as approved by the Board and recommending adoption by local districts (Attachment C).

The SCM contains several technology-forcing provisions. That is, it has standards which cannot be met at the present time, but which, based on anticipated technological developments, have future effective dates. We believe, with the TRG, that coating technology will advance sufficiently to meet these standards by the time they go into effect. There remains however, the slight but real possibility that technology will not develop within this time frame and you will want to relax or delay these limits. If the technology forcing provisions have been submitted to EPA and approved as part of the SIP, EPA may not allow a relaxation at the time you wish to make it.

An option available to you to prevent submittal of technology forcing provisions to EPA is to designate these provisions in your rule as applying only to state standards. As such, we will not submit them to EPA and you will retain the flexibility to adjust, if necessary, to a slower than anticipated pace of technology, while at the same time giving notice to the industry that these standards are indeed coming.

I have directed my staff to assist you as needed to ensure the timely adoption of this SCM. If you have any questions on the technical basis for the SCM or other matters related to it, please feel free to call Dean Simeroth, Chief, Criteria Pollutants Branch, at (916) 322-6020.

Sincerely,

James D. Boyd Executive Offi

Attachments (3)

cc: Dean Simeroth

ARB-CAPCOA Suggested Control Measure for Architectural Coatings

RULE	4	ARCHI'	アピハブリ	DAI	COATT	MCS
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(a) APPLICABILITY

This rule is applicable to any person who supplies, sells, offers for sale, applies, or solicits the application of any architectural coating, or who manufactures any architectural coating for use within the District.

(b) DEFINITIONS

- (1) Appurtenances: Accessories to an architectural structure, including, but not limited to: hand railings, cabinets, bathroom and kitchen fixtures, fences, rain-gutters and down-spouts, window screens, lamp-posts, heating and air conditioning equipment, other mechanical equipment, large fixed stationary tools and concrete forms.
- (2) Architectural Coatings: Coatings applied to stationary structures and their appurtenances, to mobile homes, to pavements, or to curbs.
- (3) Below-Ground Wood Preservatives: Coatings formulated to protect below-ground wood from decay or insect attack and which contain a wood preservative chemical registered by the California Department of Food and Agriculture.
- (4) Bituminous-Coatings: Black or brownish coating materials which are soluble in carbon disulfide, which consist mainly of hydrocarbons, and which are obtained from natural deposits or as residues from the distillation of crude oils or of low grades of coal.
- (5) Bond Breakers: Coatings applied between layers of concrete to prevent the freshly poured too layer of concrete from bonding to the layer over which it is poured.
- (6) Clear Wood Finishes: Clear and semi-transparent coatings, including lacquers and varnishes, applied to wood substrates to provide a transparent or translucent solid film.
- (7) Concrete Curing Compounds: Coatings applied to freshly poured concrete to retard the the evaporation of water.
- (8) Dry Fog Coatings (Mill White Coatings): Coatings formulated only for spray application such that overspray droplets dry before subsequent contact with other surfaces.

- (9) Exempt Solvents: Compounds identified as exempt under the definition of Volatile Organic Compounds, Subsection (b)(38).
- (10) Fire-Retardant Coatings: Coatings which have a flame spread index of less than 25 when tested in accordance with ASTM Designation E-84-87, "Standard Test Method for Surface Burning Characteristics of Building Material," after application to Douglas fir according to the manufacturer's recommendations.
- (11) Form-Release Compounds: Coatings applied to a concrete form to prevent the freshly poured concrete from bonding to the form. The form may consist of wood, metal, or some material other than concrete.
- (12) Graphic Arts Coatings (Sign Paints): Coatings formulated for and hand-applied by artists using brush or roller techniques to indoor and outdoor signs (excluding structural components) and murals, including lettering enamels, poster colors, copy blockers, and bulletin enamels.
- (13) High-Temperature Industrial Maintenance Coatings: Industrial Maintenance Coatings formulated for and applied to substrates exposed continuously or intermittently to temperatures above 400 degrees Fahrenheit.
- (14) Industrial Maintenance Anti-Graffiti Coatings: Two-component clear industrial maintenance coatings formulated for and applied to exterior walls and murals to resist repeated scrubbing and exposure to harsh solvents.
- (15) Industrial Maintenance Coatings: High performance coatings formulated for and applied to substrates in industrial, commercial, or institutional situations that are exposed to one or more of the following extreme environmental conditions:
 - (i) immersion in water, wastewater, or chemical solutions (aqueous and non-aqueous solutions), or chronic exposure of interior surfaces to moisture condensation;
 - (ii) acute or chronic exposure to corrosive, caustic or acidic agents, or to chemicals, chemical fumes, chemical mixtures, or solutions;
 - (iii) repeated exposure to temperatures in excess of 250 F;
 - (iv) repeated heavy abrasion, including mechanical wear and repeated scrubbing with industrial solvents, cleansers, or scouring agents; or
 - (v) exterior exposure of metal structures.

Industrial Maintenance Coatings are not for residential use or for use in areas of industrial, commercial, or institutional facilities such as office space and meeting rooms.

(16) Lacquers: Clear wood finishes formulated with nitrocellulose or synthetic resins to dry by evaporation without chemical reaction, including clear lacquer sanding sealers.

- (17) Magnesite Cement Coatings: Coatings formulated for and applied to magnesite cement decking to protect the magnesite cement substrate from erosion by water.
- (18) Mastic Texture Coatings: Coatings formulated to cover holes and minor cracks and to conceal surface irregularities, and applied in a thickness of at least 10 mils (dry, single coat).
- (19) Metallic Pigmented Coatings: Coatings containing at least 0.4 pounds of metallic pigment per gallon of coating as applied.
- (20) Multi-Colored Coatings: Coatings which exhibit more than one color when applied and which are packaged in a single container and applied in a single coat.
- (21) Opaque Stains: All stains that are not classified as semi-transparent stains.
- (22) Opaque Wood Preservatives: All wood preservatives not classified as clear or semi-transparent wood preservatives or as below-ground wood preservatives.
- (23) Pre-treatment Wash Primers: Coatings which contain a minimum of 1/2% acid by weight, applied directly to bare metal surfaces to provide necessary surface etching.
- (24) Primers: Coatings formulated and applied to substrates to provide a firm bond between the substrate and subsequent coats.
- (25) Residential Use: Use in areas where people reside or lodge including, but not limited to single and multiple family dwellings, condominiums, mobile homes, apartment complexes, motels, and hotels.
- (25) Roof Coatings: Coatings formulated for application to exterior roofs and for the primary purpose of preventing penetration of the substrate by water, or reflecting heat and reflecting ultraviolet radiation. Metallic pigmented roof coatings which qualify as metallic pigmented coatings shall not be considered to be in this category, but shall be considered to be in the metallic pigmented coatings category.
- (27) Sanding Sealers: Clear wood coatings formulated for and applied to bare wood for sanding and to seal the wood for subsequent application of varnish. To be considered a sanding sealer a coating must be clearly labelled as such.
- (28) Sealers: Coatings formulated for and applied to a substrate to prevent subsequent coatings from being adsorbed by the substrate, or to prevent harm to subsequent coatings by materials in the substrate.
- (29) Semi-Transparent Stains: Coatings formulated to change the color of a surface but not conceal the surface.

- (30) Semi-Transparent Wood Preservatives: Wood preservative stains formulated and used to protect exposed wood from decay or insect attack by the addition of a wood preservative chemical registered by the California Department of Food and Agriculture, which change the color of a surface but do not conceal the surface, including clear wood preservatives.
- (31) Shellacs: Clear or pigmented coatings formulated solely with the resinous secretions of the lac beetle (laccifer lacca), thinned with alcohol, and formulated to dry by evaporation without a chemical reaction.
- (32) Solicit: To require for use or to specify, by written or oral contract.
- (33) Swimming Pool Coatings: Coatings formulated and used to coat the interior of swimming pools and to resist swimming pool chemicals.
- (34) Swimming Pool Repair Coatings: Chlorinated rubber based coatings used for the repair and maintenance of swimming pools over existing chlorinated rubber based coatings.
- (35) Traffic Coatings: Coatings formulated for and applied to public streets, highways, and other surfaces including, but not limited to curbs, berms, driveways, and parking lots.
- (36) Undercoaters: Coatings formulated and applied to substrates to provide a smooth surface for subsequent coats.
- (37) Varnishes: Clear wood finishes formulated with various resins to dry by chemical reaction on exposure to air.
- (38) Volatile Organic Compounds (YOC): Compounds of carbon which may be emitted to the atmosphere during the application of and/or subsequent drying or curing of coatings subject to this rule, except methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, ammonium carbonate, 1,1,1-trichloroethane, methylene chloride, trichlorofluoromethane (CFC-11), dichlorodifluoromethane (CFC-12), chlorodifluoromethane (CFC-22), trifluoromethane (CFC-23), trichlorotrifluoroethane (CFC-113), dichlorotetrafluoroethane (CFC-114), and chloropentafluorethane (CFC-115).
- (39) Waterproofing Sealers: Colorless coatings which are formulated and applied for the sole purpose of protecting porous substrates by preventing the penetration of water and which do not alter surface appearance or texture.

(c) STANDARDS

- (1) Except as provided in Subsections (c)(2), (c)(3), and (c)(4), no person shall, within the District, supply, offer for sale, sell, apply, or solicit the application of any architectural coating which, at the time of sale or manufacture, contains more than 250 grams of volatile organic compounds per liter of coating (less water and exempt solvents, and excluding any colorant added to tint bases), or manufacture, blend, or repackage such a coating for use within the District.
- (2) Except as provided in Subsections (c)(3) and (c)(4), no person shall, within the District, supply, offer for sale, sell, apply, or solicit the application of any architectural coating listed in the Table of Standards which contains volatile organic compounds (less water and exempt solvents, and excluding any colorant added to tint bases) in excess of the corresponding limit specified in the table, after the corresponding date specified, or manufacture, blend, or repackage such a coating for use within the district.

Table of Standards (grams of VOC per liter)

Effective	Dates	
9/1/89	9/1/92	9/

	9/1/84	9/1/89	9/1/92	9/1/54
Below-Ground Wood				
Preservatives		600	250	•
Bond Breakers		750	350	••
Clear Wood Finishes		/50	350 (9/1/	90)
Lacquer		680		
Sanding Sealers		550	250	
Yarnish	500	350 350	350	
Concrete Curing Compounds	300	350 350		
Dry Fog Coatings		400		
Fire-Retardant Coatings		400		
Clear	<u> </u>	650.		
Pigmented		350 350		
Form-Release Compounds	•	250		
Graphic Arts (Sign) Coatings		500		
Industrial Maintenance Coating	·	420	240	
Industrial Maintenance	•	420	340	
Anti-Graffitti Coatings		600	240	
High Temperature Industrial			340	
Maintenance Coatings		650	550	100
Magnesite.Cement Coatings		600	450	420
Mastic Texture Coatings		300	450	•
Metallic Pigmented Coatings		500		
Muiti-Color Coatings		580	420	
Opaque Stains	400	350	440	
Opaque Wood Preservatives	400	350		
Pre-treatment Wash Primers		780	780	420
Primers Sealers & Undercoaters	400	350	780	420
Roof Coatings		300		
Semi-transparent Stains		350		
Semi-transparent and Clear		550		
Wood Preservatives		350		
Shellac				
Clear		730		
Pigmented		550		
Swimming Pool Coatings		650	340 (9/1/92	1
Repair and Maintenance			0,0 (3,1,32	•)
Coatings		650	340 (9/1/97	١
Traffic Paints			0.0 (3/1/3/	, ·
Public streets & highways	415	25 0		
Other surfaces	250	250		
Black traffic coatings	-	250		
Waterproofing Sealers		400		

- (3) If anywhere on the container of any coating listed on the Table of Standards, on any sticker or label affixed thereto, or in any sales or advertising literature, any representation is made that the coating may be used as, or is suitable for use as a coating for which a lower YOC standard is specified in the table or in Subsection (c)(1), then the lowest YOC standard shall apply. This requirement does not apply to the representation of the following coatings in the manner specified:
 - (i) 'High-Temperature Industrial Maintenance Coatings, which may be represented as metallic pigmented coatings for use consistent with the definition of high temperature industrial maintenance coatings;

(ii) Lacquer Sanding Sealers, which may be recommended for use as sanding sealers in conjunction with clear lacquer topcoats;

- (iii) Metallic Pigmented Coatings, which may be recommended for use as primers, sealers, undercoaters, roof coatings, or industrial maintenance coatings; and
- (iv) Shellacs.
- (4) Sale of a coating manufactured prior to the effective date of the corresponding standard in the Table of Standards, and not complying with that standard, shall not constitute a violation of Subsection (c)(2) until three years after the effective date of the standard, nor shall application of such a coating.
- (5) All YOC-containing materials shall be stored in closed containers when not in use. In use includes, but is not limited to: being accessed, filled, emptied, maintained or repaired.

(d) ADMINISTRATIVE REQUIREMENTS

- (1) Each container of any coating subject to this rule shall display the date on which the contents were manufactured or a code indicating the date of manufacture. Each manufacturer of such coatings shall file with the Air Pollution Control Officer and the Executive Officer of the California Air Resources Board, an explanation of each code.
- (2) Each container of any coating subject to this rule shall display a statement of the manufacturer's recommendation regarding thinning of the coating. This recommendation shall not apply to the thinning of architectural coatings with water. The recommendation shall specify that the coating is to be employed without thinning or diluting under normal environmental and application conditions unless any thinning recommended on the label for normal environmental and application conditions does not cause a coating to exceed its applicable standard.

- (3) Each container of any coating subject to this rule and manufactured after (one year from the date of adoption) shall display the maximum VOC content of the coating, as applied, and after any thinning as recommended by the manufacturer. VOC content shall be displayed as grams of VOC per liter of coating (less water and exempt solvent, and excluding any colorant added to tint bases). VOC content displayed may be calculated using product formulation data, or may be determined using the test method in Subsection (f)(1).
- (4) Beginning (one year from the date of adoption), the labels of all industrial maintenance coatings shall include the statement "Not for Residential Use," or "Not for Residential Use in California," prominently displayed.

(e) EXEMPTIONS

The requirements of this rule do not apply to:

- (1) Architectural coatings manufactured for use outside of the District or for shipment to other manufacturers for repackaging.
- (2) Architectural coatings supplied in and applied from containers having capacities of one liter or less, which were offered in containers of such capacities prior to (the date of adoption of this rule).
- (3) Architectural coatings sold in non-refillable aerosol containers having capacities of one liter or less.
 - (4) Emulsion-type bituminous pavement sealers.

(f) TEST METHODS

(1) Volatile Organic Compounds: Measurement of volatile organic compounds in architectural coatings shall be conducted and reported in accordance with EPA Test Method 24 (40 CFR 60, Appendix A), or an equivalent method approved by the air pollution control officer.

Revisions to Technical Support Document

VII.

DISCUSSION OF PROPOSED AMENDMENTS

- A. DEFINITIONS / STANDARD PROPOSALS
- Graphic Arts Coatings (Revised from April 21)

RECOMMENDATION

Revise the graphic arts coating definition as follows:

Graphic Arts Coatings (Sign Paints): Coatings formulated for and hand-applied by artists using brush or roller techniques to indoor and outdoor signs (excluding structural components) and murals, including lettering enamels, poster colors, copy blockers, and bulletin enamels.

Proposed YOC Limit: 500 q/l

Current YOC Limit: Exempt (Current level about 500 g/l)

BASIS FOR RECOMMENDATION

Our first proposal was to establish the graphic arts standard at 400 g/l. However, discussions with respondents to the 1984 survey revealed errors in the reported YOC values, particularly with regards to thinning. In light of this new information, we raised the standard from the proposed 400 g/l to 500 g/l to allow artists the latitude necessary for thinning. To improve the clarity and enforceability of the rule, the definition has been expanded to include other applications of graphic arts coatings, including murals and use as copy blockers and specifically exclude those components of a sign that do not require graphic arts coatings.

ISSUES

This is a very small category with limited application and the 1984 survey may reflect usage of graphic arts coatings for non-architectural application. We intend to further investigate the use of graphic arts coatings on architectural structures and revisit this category in three years to investigate further emission reductions.

It was requested consideration be given to restructuring of the coating rules to better address the use of graphic arts coatings. Currently, graphic arts coatings are subject to several rules depending on the district in which it is being applied, what substrate they are applied to and where they are applied. As an example, in districts having metal parts and products rules, a graphic arts coatings applied to a metal sign in a shop situation would be subject the metal parts and products rule. If the same coating is applied to a wooden sign in a shop it would fall under district wood product rules, or if a plastic sign is painted in a shop situation, a plastic parts and product rule standard would have to be met. On the other hand, if a sign is painted after installation, it is considered an architectural structure and, regardless of the substrate, the graphic arts coating would be subject to an architectural coating rules. As can be seen from this example, suppliers of these coatings, coating users, and air pollution enforcement officials must interpret a myriad of rules when dealing with graphic arts coatings. The Technical Review Group recognizes the above problems but, and has tried to establish a definition which takes into account the needs of the sign-painting industry without allowing wholesale use of high-solvent paints, for jobs which do not legitimately constitute sign painting within the meaning of the rule.

25. Industrial Mainternance Anti-Graffiti Coatings (New)

RECOMMENDATION

Include a special category for anti-graffiti coatings:

Industrial Maintenance Anti-Graffiti Coatings: Two-component clear industrial maintenance coatings formulated for and applied to exterior walls and murals to resist repeated scrubbing and exposure to harsh solvents.

BÁSIS FOR RECOMMENDATION

The Air Resources Board directed the inclusion of this category at its meeting on May 12, 1989, at which it considered the suggested control measure for architectural coatings.

26. Sanding Sealers (New)

RECOMMENDATION

Include a special category for sanding sealers for use under varnishes, as follows:

Sanding Sealers: Clear wood coatings formulated for and applied to bare wood for sanding and to seal the wood for subsequent application of varnish. To be considered a sanding sealer a coating must be clearly labelled as such.

BASIS FOR RECOMMENDATION

The Air Resources Board directed the inclusion of this category at its meeting on May 12, 1989, at which it considered the suggested control measure for architetctural coatings.

- B. ADMINISTRATIVE PROPOSALS
- 4. On-site Coating of Uninstalled Appurtenances (delete)

Table 6
Estimated Statewide Emission Reductions

Coating Category	VCC Limit, g/i	1984 Extinated Statewide Existions Tone/Year	Extimated Emission Reductions Tons/Year	Future Effective VCC Limit, g/1	Additional Emission Reductions Tons/Year
Roof Coatings	300	3.331	318		
Metallic Pigmented Coatings	588	69	2		
Primers, Segiers & Undercogters	350	2,552	486		
Enomel Undercoaters (Consolidate with P. S & U)	250	, 898	. 48		·
Quick—Dry Primers, Sealers & Undercoaters (Consolidate with P.S & U)	350	495	165		
Specialty Flat (Consolidate with P, S ≥ U)	358	68	13.6		
Industrial Maintenance (IM)	428	5,595	712	340	813
Clear Wood Finishes - Varmish - Lacquer	350 . 588	2,815 5.516	558 • 24		3.5
Previously Exempt Categories		1			,
Below Ground Wood Preservative	ves 358	4	0.2	350	2
Bond Breckers	500	444	0.8	350	185
Dry Fog Coatings	400	116	7.2		
Fire Retardant Coatings	658	14	⊲1.1		
Graphics Arts	588	92	⊲1.1		
Mostic Texture Coatings	. 388	465	16		
Hulti-Calared Coatings	588	· 296	32	428	45
Sheilac — Clear — Pigmented	730 ,550	184 111	<8.1 8.9		
Swimming Pool Coatings	650	181	8	348	74
Tile-Like Glaze . (Consolidate with IM)	428	41	8	348	4.3
Quick Dry Enomets (Consolidate with NormFlat)	258	645	258		
Wood Preservatives	350	1,441	158		
Stains	350	5.224	<u>495</u>		
Nates		Total: 29.645 (81 tons/day)	3,223 (8.8 tons/day)	(1,123 3.1 tons/day)

Assumes VCC content reduced to, but not below, new standard; does not consider clean—up solvent reductions.

P. S & U = Primers. Segiers and Undercoaters



CALIFORNIA AIR POLLUTION CONTROL OFFICERS ASSOCIATE

June 13, 1989

PRESIDENT CONTRACTOR ASSESSMENT

MMEDIATE PART MESIDENT. PICTURE BALDION

PHESIDENT-ELECT Waller Mode

TECRETARY/CHIEF FINANCIAL OFFICER Lance Lance

YICE-PRESIDENT HOSTORY PRINCIP

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VICE-PRESIDENT

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SALITIZE MECTER. illwan Wilson 222 Western Onve Limeron Park CA 95682 1141 475-4323

James D. Soyd Executive Officer Air Resources Board P.O. Bax 2815 Sacramento, CA 95814

Dear Mr. Soya:

Subject: Suggested Control Measure for Architectural Coatings

The TRG, as required by the Memorandum of Understanding between the CAPCOA and the ARB, has considered the changes the ARB made to the SCM for Architectural Coatings at the Board's May 12, 1989 public meeting.

The TRG finds the SCM as changed to be acceptable. The TRG also strongly recommends that the SCM be forwarded to appropriate air pollution control districts for their consideration. In reviewing the suggested control measure as revised by the Air Resources Board, individual TRG members expressed concern about two of the revisions. The Board changed the standards proposed for lacquers to remove the future effective standards with a request to review the limits prior to the proposed implementation dates. This will eliminate the reduction of approximately 2 tons per day of volatile organic compound emissions in 1993. The TRG plans to reevaluate this category by 1992 and, if appropriate, will ask the Board to consider establishing new lower stangards for lacquers. The other concern expressed by several districts was the change made by the Board to increase the time from two years to three years to clear store sneives of noncomplying products. This change primarily reflects on the enforceability of the rule. The TRG will also review the impact of this change as part of its review to determine the opportunity for additional emission reductions.

The TRG will continue to work with ARB staff to develop information, to refine our emission inventory, and to improve our data base on volatile organic content of coatings. This information will provide the casis for the review of architectural coatings planned for 1992.

If you have any questions, feel free to contact me at (415) 771-6000, ext. 315.

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James R. Gulhrie, Chairman

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APPENDIX B

SURVEY QUESTIONNAIRE

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AIR RESOURCES BOARD 2020 L STREET P.O. BOX 2815 SACRAHENTO, CA 95812



February 3, 1993

Dear Sir or Madam:

The Air Resources Board (ARB) is conducting a survey of architectural and industrial maintenance (AIM) coatings sold in California. As you may know, surveys of architectural and industrial maintenance coatings by the ARB were previously conducted in 1985 and 1989. This survey, in which we are requesting 1990 data, will assist ARB to continually assess the volatile organic compound emissions in California from the use of AIM coatings.

Please complete the attached survey forms according to the instructions provided. If you do not sell any coating that is sold in California, complete only Form I. Please submit the completed survey to the ARB by <u>March 19, 1993</u> at the following address:

California Air Resources Board P.O. Box 2815, Sacramento, CA 95812 Attention: Solvents Control Section

This request for information is made pursuant to Sections 39607, 39701 and 41522 of the California Health and Safety Code, and Title 17, California Code of Regulations, Section 91100. These sections authorize the ARB to require the submission of information needed by the Board to estimate atmospheric emissions and to carry out its other statutory responsibilities. Information which you note as confidential shall be protected in accordance with Title 17, California Code of Regulations, Section 91000 to 91022 and the California Public Records Act (Government Code Section 6250 et seq.). If you are designating any information contained in your survey as confidential, please complete and sign the attached Confidentiality Information Submittal Form.

If you have any questions concerning the survey, please call Peggy Vanicek, Manager of the Solvents Control Section, at (916) 322-8283 or Peter Liu, Air Resources Engineer, Solvents Control Section, at (916) 327-1516.

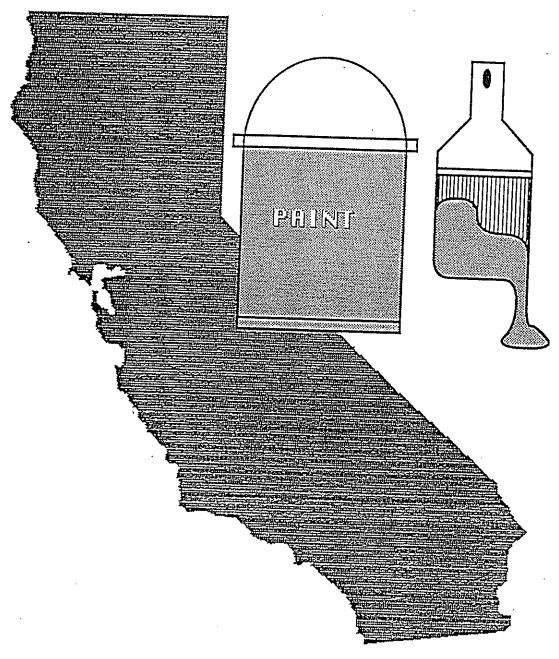
Sincerely,

Dean C. Simeroth, Chief Criteria Pollutants Branch Stationary Source Division

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Architectural and Industrial Maintenance Coatings Survey

- Survey Packet -



CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Air Resources Board

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SURVEY PACKET CONTENTS

California Air Resources Board - Architectural and Industrial Maintenance Coatings Survey

The Survey Packet contains the following:

Survey Instructions

1.	General Instructions for Completing the Survey Forms	. 2	
2.	Instructions for Completing Survey Form II	3	
2.	Definition of Survey Terms	6	
3.	Calculations	10	
4.	Example of Completed Survey Form II	12	

Appendices - Survey Forms

- A. Survey Form I
- B. Survey Form II
- C. Confidential Information Submittal Form

You can request a Quattro-Pro 3.0 software Survey Form II by mailing an unformatted 3" diskette with a self addressed diskette mailer to:

California Air Resources Board P.O. Box 2815, Sacramento, Ca. 95812 Attention: Solvents Control Section

GENERAL INSTRUCTIONS FOR COMPLETING THE SURVEY FORMS California Air Resources Board - Architectural and Industrial Maintenance Coatings Survey

Please complete the attached survey forms. Please answer the applicable questions on Form I even if you do not sell, or manufacture for sale, any architectural or industrial maintenance coatings to California. Complete Form II for all architectural or industrial maintenance coating products that you have sold, or sold to another party for sale, in California in 1990. Please photocopy Form II if additional copies are necessary.

In reporting products for the survey, coatings in a coating category can be reported either individually or as a group. However, you may group coatings in a category together only if the following conditions are met:

- (1) The coatings have VOC contents (less water and less exempt compounds) that are within one VOC range. VOC ranges are defined on page 2.
- (2) The coatings have the same carrier technology (e.g. solvent-based, water-based, 100% solids, etc.)

In reporting the grouped coatings as one entry, the sales weighted average VOC and solids contents should be reported. Pages 10-11 contain equations that can be used to calculate sales weighted average, VOC content and solids content. Page 12 contains an example of a completed Form II.

Please Return the completed survey to the following address by March 19, 1993:

California Air Resources Board
Stationary Source Division
P.O. Box 2815
Sacramento, CA 95812
Attn: Solvents Control Section

If you have any questions or other requests please call:

Peter Liu (916) 327-1516 Julie Billington (916) 327-0650 Peggy Vanicek (916) 322-8283

INSTRUCTIONS-FOR COMPLETING SURVEY FORM II

California Air Resources Board - Architectural and Industrial Maintenance Coatings Survey

Please follow the instructions below to complete items (A) through (N) on Survey Form II for all architectural and industrial maintenance coatings that your company have sold in California, or sold to another party for sale in California, in 1990. See page 12 for an example of a completed Form II.

- (A) Entry Number Enter an integer starting from 1 for each entry into the survey form.
- (B) Coating Code Enter the code from the list below which best represents the reported coatings' coating category (see pages 6-9 for definitions of the categories below).

<u>Cod</u>	e Coating	<u>Code</u>	Coating
1.0 2.0 3.0 4.1 4.2 4.3 5.0 6.0 7.1 7.2 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0	Anti-Graffiti Coating Below-Ground Wood Preservatives Bond Breakers Clear Wood Finishes: Lacquers Sanding Sealers Varnishes Concrete Curing Compounds Dry Fog Coatings Fire Retardant Coatings: Clear Pigmented Flats Form-Release Compounds Graphic Arts (sign) Coatings High Temperature Coatings Industrial Maintenance Coatings Magnesite Cement Coatings Mastic Texture Coatings Metallic Pigmented Coatings Multi-color Coatings Nonflats: High Gloss Medium Gloss Low Gloss	18.0 19.0 20.0 21.0 22.0 23.0 24.0 25.0 26.1 26.2 27.0 28.0 29.0 30.1 30.2 31.0	Opaque Stains Opaque Wood Preservatives Pre-treatment Wash Primers Primers Sealers and Undercoaters
17.4	Quick Dry Enamels		

(C) VOC Content Range - Enter the VOC range code from below for the coating or group of coatings being reported as one entry. The VOC content referred to here is the regulatory VOC content, less water and less exempt compounds. This can be estimated from the chemical composition data or determined by EPA Method 24, 40 CFR Part 60, as amended in Federal Register Vol. 57, No. 133, July 10, 1992, or ASTM D 3960-92.

Rang		<u>Range</u>	<u>Range</u>
Code		<u>Code</u> <u>g/l</u>	<u>Code</u> <u>g/l</u>
	0 - 50	6 251 - 300	11 501 - 550
	51 - 100	7 301 - 350	12 551 - 600
	101 - 150	8 351 - 400	13 601 - 650
4 5	151 - 200 201 - 250	9 401 - 450	14 651 - 700
5	201 - 200	10 451 - 500	15 701 and above

- (D) Number of Products Grouped Enter the number of individual coatings that are grouped as one entry. Color varieties of a coating that do not vary significantly in VOC contents should not be considered individual coatings. Enter 1 if you are reporting one coating individually.
- (E) Interior/Exterior Indicate whether the coating or coatings are designed for exterior or interior application by entering "E" or "I" accordingly. Enter "D" for dual purpose interior/exterior products.
- (F) Specialty Substrate or Surface Answer "Yes" only if the coating(s) reported are products formulated for and designed to be applied on specific substrates or surfaces that is not already specified by the coating category definition. Note the specialty substrates or surfaces in (N) Comments. Answer "No" if the coating(s) are used for multiple substrates and surfaces.
- (G) Carrier Technology Enter the code from the list below which represent the carrier technology of the coating(s).
 - 1. Solvent-based

- 3. Water-based
- 2. Solvent-based with Exempt Compounds
- 4. 100% Solids

- (H) Resin Code Enter a code or codes from the list below which best represent the primary resin type(s) of the coating(s) reported.
 - (1) Acrylics **Epoxies** (14) Urethanes, (2) Alkyds (8) Oleoresins Polyurethanes (3) Modified Alkyds (9) Phenolics (15) Vinyls (4) Amines, Amides (10) Polyesters (16) Vinylidene Chloride (5) Cellulosic (11) Shellacs (17) Other (Note other (6) Chlorinated Rubber (12) Silicone, Silanes resin type in

(N) Comments.)

(I) % Volume Solids - Enter the sales weighted average solids content of the coating(s) as percent of total coating volume. See page 10-11 for equations.

(13) Styrenic

- (J) VOC of Material Enter the sales weighted average VOC content of the coating(s), as supplied, in grams of VOC per liter of Material. Do not report VOC content on a less water basis as would be for compliance determination. See page 10 for equation.
- (K) VOC Maximum Thinning Enter the sales weighted average VOC content at maximum recommended thinning of the coating(s) in grams of VOC per liter of Material. "Maximum Recommended Thinning" is the highest level of thinning by VOC containing solvents that is recommended by information appearing on the coating can, label, or any other accompanying literature from the manufacturer. See page 10 for equation.
- (L) VOC Less Water Less Exempt Enter the sales weighted average regulatory VOC content of the coatings(s), as applied, in grams of VOC per liter of coating, less water and less exempt compounds. This may be determined from the chemical composition data or by EPA Method 24, 40 CFR Part 60, as amended in Federal Register Vol. 57, No. 133, July 10, 1992, or ASTM D 3960-92. See page 10 for equation.
- (M) Annual Sales Enter the California sales of the coating, in gallons per year, from the calendar year 1990. Report the sales of coatings sold in <u>Small Containers</u>, which are those one liter (1.1 quarts) or less, separately from those sold in larger containers. Include all coatings that your company sold in California or sold to another party for sale in California during the calendar period of reporting.
- (N) Comments Enter any information that was designated as comments for (B), (F), (H). Enter also any information that you wish to provide in addition to those entered into (B) through (M). Reference the comment with its corresponding entry number from (A) and its corresponding reporting item code (e.g. (B), (F), or (H)).

DEFINITION OF SURVEY TERMS

California Air Resources Board - Architectural and Industrial Maintenance Coatings Survey

Anti-Graffiti Coatings: Industrial maintenance coatings formulated for and applied to exterior surfaces to resist repeated scrubbing and exposure to harsh solvents and cleaners used to remove graffiti.

Architectural Coatings: Coatings applied to stationary structures and their appurtenances, to mobile homes, to pavements, or to curbs.

Below-Ground Wood Preservatives: Coatings formulated to protect below-ground wood from decay or insect attack and which contain a wood preservative chemical registered by the California Department of Pesticide Regulation.

Bituminous Coating: Black or brownish coating materials which are soluble in carbon disulfide, which consists mainly of hydrocarbons, and which are obtained from natural deposits or as residues from the distillation of crude oils or of low grades of coal.

Bond Breakers: Coatings applied between layers of concrete to prevent the freshly poured top layer of concrete from bonding to the layer over which it is poured.

Clear Wood Finishes: Clear and semi-transparent coatings, including lacquers and varnishes, applied to wood substrates to provide a transparent or translucent solid film.

Concrete Curing Compounds: Coatings applied to freshly poured concrete to retard the evaporation of water.

Dry Fog Coatings: Coatings formulated only for spray application such that overspray droplets dry before subsequent contact with other surfaces.

Exempt Compounds: Any compound which has been specified as exempt compounds in the definition for "Volatile Organic Compounds."

Fire-Retardant Coatings: Coatings which have a flame spread index of less than 25 when tested in accordance with ASTM Designation E-84-87, "Standard Test Method for Surface Burning Characteristics of Building Material," after application to Douglas Fir according to the manufacturer's recommendations.

Flat Architectural Coatings: Coatings which register a gloss of less than 15 on an 85 degree meter or less than 5 on a 60 degree meter.

Form Release Compounds: Coatings applied to a concrete form to prevent the freshly poured concrete from bonding to the form. The form may consist of wood, metal, or some material other than concrete.

Graphic Arts Coatings (Sign Paints): Coatings formulated for and hand-applied by artists using brush or roller techniques to indoor and outdoor signs (excluding structural components) and murals, including lettering enamels, poster colors, copy blockers and bulletin enamels.

High Temperature Coatings: Industrial maintenance coatings formulated for and applied to substrates exposed continuously or intermittently to temperatures above 400° F.

Industrial Maintenance Coatings: High performance coatings formulated for and applied to substrates in industrial, commercial, or institutional situations that are exposed to one or more of the following extreme environmental conditions:

- immersion in water, waste water, or chemical solutions (aqueous and non-aqueous (i) solutions), or chronic exposure of interior surfaces to moisture condensation;
- acute or chronic exposure to corrosive, caustic or acidic agents, or to chemicals, (ii) chemical fumes, chemical mixtures, or solutions;
- repeated exposure to temperatures in excess of 250° F; (iii)
- repeated heavy abrasion, including mechanical wear and repeated scrubbing with industrial solvents, cleansers, or scouring agents; or
- exterior exposure of metal structures. (v)

Industrial Maintenance Coatings are not for residential use or use in areas of industrial, commercial, or institutional facilities which do not experience industrial environmental conditions such office space and meeting rooms.

Lacquers: Clear wood finishes formulated with nitrocellulose or synthetic resins to dry by evaporation without chemical reaction, including clear lacquer sanding sealers.

Magnesite Cement Coatings: Coatings formulated for and applied to magnesite cement decking to protect the magnesite cement substrate from erosion by water.

Mastic Texture Coatings: Coatings formulated to cover holes and minor cracks and to conceal surface irregularities, and applied in a thickness of at least 10 mils (dry, single coat).

Metallic Pigmented Coatings: Coatings containing at least 0.4 pounds of metallic pigment per gallon of coating as applied.

Multi-Colored Coatings: Coatings which exhibit more than one color when applied and which are packaged in a single container and applied in a single coat.

Nonflat Architectural Coatings: Coatings which register a gloss of 15 or greater on an 85 degree meter or 5 or greater on a 60 degree meter.

Nonflats - high gloss: Nonflat coatings which register a gloss of 70 or greater on a 60 degree meter.

Nonflats - medium gloss: Nonflat coatings which register a gloss of 20 or more but less than 70 on a 60 degree meter.

Nonflats - low gloss: Nonflat coatings which register a gloss greater than 5 but less than 20 on a 60 degree meter.

Nonflats - Quick Dry Enamels: Non-flat coatings which comply with the following:

- (i) capable of being applied directly from the container by brush or roller under normal conditions, normal conditions being temperatures between 60°F and 80°F.
- (ii) when tested in accordance with ASTM D 1640, they shall: set to touch in two hours or less, dry hard in eight hours or less, and be tack free in four hours or less by the mechanical test method.
- (iii) shall have a 60 degrees F dried film gloss of 70 or above on a 60 degree meter.

Opaque Stains: All stains other than semi-transparent stains

Opaque Wood Preservatives: All wood preservatives other than clear, semi-transparent or below-ground wood preservatives.

Pre-treatment Wash Primers: Coatings which contain a minimum of 0.5% acid by weight, applied directly to bare metal surfaces to provide necessary surface etching.

Primers: Coatings formulated and applied to substrates to provide a firm bond between the substrate and subsequent coats.

Quick Dry Primers, Sealers and Undercoaters: Primers, sealers and undercoaters which are dry to touch in one-half hour and can be recoated in two hours, when tested in accordance with ASTM D1640.

Roof Coatings: Coatings formulated for application to exterior roofs and for the primary purpose of preventing water penetration, or reflecting heat or ultraviolet radiation.

Sanding Sealers: Clear wood coatings formulated for and applied to bare wood for sanding and to seal the wood for subsequent application of varnish.

Sealers: Coating formulated for and applied to a substrate to prevent subsequent coatings from being absorbed by the substrate, or to prevent harm to subsequent coatings by materials in the substrate.

Semi-transparent Stains: Coatings formulated to change the color of a surface but not to conceal the surface.

Semi-transparent and Clear Wood Preservatives: Wood preservative stains which protect exposed wood from decay or insect attack by the use of a preservative chemical registered with the California Department of Pesticide Regulation, and which may change the color of a surface but do not conceal the surface.

Shellacs: Clear or pigmented coatings formulated solely with the resinous secretions of the lac beetle (laccifer lacca), thinned with alcohol, and forms a film by solvent evaporation without chemical reaction.

Swimming Pool Coatings: Coatings formulated and used to coat the interior of swimming pools and is compatible with swimming pool water chemistry.

Swimming Pool Repair Coatings: Chlorinated rubber based coatings used for the repair and maintenance of swimming pools over existing chlorinated rubber based coatings.

Traffic Coatings: Coatings formulated for and applied to public streets, highways and other surfaces traveled by vehicle traffic.

Undercoaters: Coatings formulated and applied to substrates to provide a smooth surface for subsequent coats.

Varnishes: Clear wood finishes formulated with various resins to dry by chemical reaction on exposure to air.

Volatile Organic Compound (VOC): Any compound containing at least one atom of carbon, except methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides, or carbonates, ammonium carbonate, and including the following exempt compounds which have been determined to have negligible photochemical reactivity: 1,1,1-trichloroethane, methylene chloride, trichlorofluoromethane (CFC-11), dichlorodifluoromethane (CFC-12), chlorodifluoromethane (HCFC-22), trifluoromethane (HFC-23), 1,1,1-trichloro-2,2,2trifluoroethane (CFC-113), 1-chloro-1,1-difluoro-2-chloro-2,2-difluoroethane (CFC-114), chloropentafluoroethane (CFC-115), 2,2-dichloro-1,1,1-trifluoroethane (HCFC-123), 1,1,1,2tetrafluoroethane (HFC-134a), 1,1-dichloro-1-fluoroethane (HCFC-141b), 1-chloro-1,1difluoroethane (HCFC-142b), 2-chloro-1,1,1,2-tetrafluoroethane (HCFC-124), pentafluoroethane (HFC-125), 1,1,2,2-tetrafluoroethane (HFC-134), 1,1,1-trifluoroethane (HFC-143a), 1,1-difluoroethane (HFC-152a), the following classes of perfluorocarbons: (A) cyclic, branched, or linear, completely fluorinated alkanes; (B) cyclic, branched, or linear, completely fluorinated ethers with no unsaturations; (C) cyclic, branched or linear, completely fluorinated tertiary amines with no unsaturations; and (D) sulfur-containing perfluorocarbons with no unsaturations and with the sulfur bonds only to carbon and fluorine.

Waterproofing Sealers: Coatings which are formulated and applied for the sole purpose of protecting porous substrates by preventing the penetration of water, and which do not alter the appearance or texture of the substrate.

California Air Resources Board - Architectural and Industrial Maintenance Coatings Survey

VOC Content Calculations

The following are equations that can be used to calculate the VOC content entries to (J) and (L) in the Survey Form.

$$VOC_{Accusal} = \frac{W_s - W_w - W_e}{V_m} \quad (J)$$

$$VOC_{less water, less exempt} = \frac{W_s - W_w - W_c}{V_m - V_w - V_c}$$
 (L)

Where:

W_s = Weight of volatile materials (VOC+water+exempt compounds), in grams

 W_w = Weight of water in the coating, in grams

 W_{ϵ} = Weight of exempt compounds, in grams

 V_m = Volume of the coating, in liters

 $V_{\rm w}$ = Volume of water in the coating, in liters

 V_c = Volume of exempt compounds in the coating, in liters

VOC After Maximum Thinning

The following equation can be used to calculate the entry to (K) for coatings thinned with VOC containing solvents.

Where:

 $VOC_{conting}$ = Actual VOC content of coating, in grams per liter of material $VOC_{thinner}$ = Actual VOC content of thinner, in grams per liter of material

Percent Volume of Solids

The following are two equations that can be used to calculate the percent volume of solids for reporting to item (I) in the survey form. The choice of equation depends on the type of information that is known about the coating.

(1) If the weight and density of all of the solid (nonvolatile) materials are known, then the following equation may be used:

Percent Volume of Solids =
$$\frac{\text{Weight of Solids}}{\text{Density of Solids x Volume of Coating Material}} \times 100$$
 (I₁)

Percent Volume of Solids (Continued)

(2) If instead, only the volatile components of a coating (VOC, water and exempt compound) are known, the percent volume of solids may be estimated by the following equation.

Percent Volume of Solids =
$$\left(1 - \frac{W_w}{D_w \times V_m} - \frac{W_v}{D_v \times V_m} - \frac{W_e}{D_e \times V_m}\right) \times 100$$
(I₂)

Where:

 W_{*} = Weight of water in the coating, in grams

 W_{ν} = Weight of VOC in the coating, in grams

 W_{ϵ} = Weight of exempt compounds in the coating, in grams

 D_w = Density of water, in grams per liters D_v = Density of VOC, in grams per liters

 D_e = Density of exempt compounds, in grams per liters

 V_m = Volume of the coating, in liters

Sales Weighted Average Calculation

The Sales Weighted Average (SWA) is an average value for grouped coatings, calculated by weighing the individual values by their sales. For this survey, the SWA should be used to report entries to (I), (J), (K), and (L) for coatings that are grouped as one entry. Coatings can be grouped only if their VOC contents are within the same VOC range and if they are based on the same carrier technology. The following equation can be used to calculate Sales Weighted Average.

$$SWA = \frac{(Value_1 \times Sales_1 + Value_2 \times Sales_2 + ... + Value_n \times Sales_n)}{Sales_1 + Sales_2 + ... + Sales_n}$$

Where:

Value_(1,2,...n) = Coating characteristic values (e.g. VOC contents, Percent Volume

Sales_(1,2,...n) of Solids) for products 1,2,...n = Sales for products 1,2,...n

Conversion Factors

grams/Liter = $120 \times lbs/gallon$

gallon = $3.8 \times \text{liter}$ lbs = $454.5 \times \text{grams}$

O Air Resources Board

ARCHITECTURAL AND INDUSTRIAL MAINTENANCE COATINGS SURVEY - FORM II

EXAMPLE OF COMPLETED SURVEY FORM II (see page 13 for the data used for the entries)

Instructions for completing this form are in Pages 3-5 of the Survey Packet.

Confidential? Yes [V] No [(M)	E 6	or 1.1 Quart Liter or less	730,000	58,000		40,000		25,000			
	1 (1)	VOC	<u> </u>		082 991	338 58		260 40,		234 25			
	(8)	Noc	Ę %		104	338 3		2 072		7116		, L	
	6		VOC of Material	104	·	290		77.60				/	
	(E)		% Volume Solids	4.2	<u>}</u>			1001	Y	97			
	(11)	0	Code(1)	1,15		4		7		1,15		-	
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The second control of ackel.		Substrate/	Surface (Y or N)	7		Z		➣.		>-			
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(2)	<u> </u>		(1.0-31.0)	17,2		12.0		30.1		8.0			
3		:	Enlry			7		Μ		4			

If the Code for "Other" is entered into either (B) or (H), note the "other" as a comment in (N) below.

If you answered "Yes" to (F), enter the specially substrate or surface as a comment in (N) below

(N) | Comments: Reference each comment with its "Entry #" from (A) and reporting item code (e.g. (B), (F) or (H)). Continue on the back if additional space is necessary.

Enly #: (3) (3) (K)+ (L) VOC by ASTM D5095-90 + BAAAMD 31 (A) Concrete + Masonry Only

Enig#: (4) (F) Cerling Paint

- SAMPLE ONLY -

EXAMPLE OF COMPLETED SURVEY FORM II California Air Resources Board - Architectural and Industrial Maintenance Coatings Survey

The following is the data that corresponds to the codes entered into the example Survey Form II on the previous page. This data is provided only to help you understand how the survey form should be completed. You do not have to provide such data for the survey.

Item # Coating Description

- (B) Interior nonflat medium gloss; (C) VOC range: 201-250 g/I less water and less exempt compounds; (D) 3 products grouped; (E) Interior; (F) No specialty substrate or surface, multipurpose paint; (C) Water-based latex emulsion; (H) Vinyl acrylic resins; (I) % volume solids; product I = 40, product II = 38, product III = 48, Sales Weighted Average (SWA) = 43; (J) VOC of Material (g/I): I = 80, II = 100, III = 120, SWA = 104; (K) No thinning; (L) VOC less water and less exempt: I = 120, II = 160, III = 180, SWA = 160; (M) Sales in > 1 liter containers (gail: 1 = 50,000, III = 80,000, III = 100,000, Total = 230,000.
- 2. (B) Industrial mannenance; (C) VOC range: 301-350 g/l; (D) 1 individual product; (E) Exterior (F) Multipurpose coating; (G) Solvent-based; (H) Two component acrylic aliphatic urethane resins; (I) % Volume solids = 67; (J) VOC of Material = 290 g/l; (K) VOC after maximum thinning = 338 g/l (thinned by 10% or 0.1 gal thinners per gallon of coating, thinner VOC = 820 g/l); (L) Same as in (K); (M) Sales in > 1 liter containers (gal) = 58,000.
- (B) Clear waterproofing sealer; (C) VOC range: 251-300; (D) 1 individual product; (E) Exterior; (F) Designed for specific substrates; (G) 100 % solids; (H) Silanes; (I) % Volume Solid = 100; (J) VOC emission of material = 260 g/l; (K) Same as in (J); (L) Same as in (J); (M) Sales in > 1 liter containers (gal) = 40,000, Sales in < 1 liter containers = 10,000 gal.; (N) For use on concrete and masonry only; VOC determined by ASTM D 5095-90 and Bay Area Air Quality Management District Method 31.
- 4. (B) Interior flat; (C) VOC range (g/l): 201-250; (D) 2 products grouped; (E) Interior; (F) For use on ceilings; (G) Water-based latex emulsion; (H) Vinyl acrylic resins; (I) % Volume solids: product I = 25, product II = 28, SWA = 26; (J) VOC of material: I = 110, II = 125, SWA = 116; (K) No recommended thinning; (L) VOC less water less exempt(g/l): I = 230, II = 250, SWA = 239; (M) Sales in > 1 L containers: I = 20,000, II = 15,000, total = 35,000; (N) For use on ceilings only.

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Architectural and Industrial Maintenance Coatings Survey - Appendices (Survey Forms) -

Complete the Following Survey Forms and Return to ARB



CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Air Resources Board

Return by March 19, 1993 to:

California Air Resources Board P.O. Box 2815 Sacramento, CA 95812

Atm: Solvents Control Section

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FORM I

California Air Resources Board - Architectural and Industrial Maintenance Survey

ase answer the following questions:
Does your company manufacture architectural and industrial maintenance coatings for sale in California, or distribute such coatings in California?
[] Yes [] No (If "No" skip 2-4 and answer 5-6)
Company marketing classification.
[Interstate
Company Size: (Check the range of typical annual sales and number of employees)
[] < \$5 Million [] \$5-10 Million [] \$10-50 Million [] > \$50 Million
[] < 100 Employees [] 100-500 Employees [] > 500 Employees
How will you estimate or report California Sales?
By actual sales Apportion national Sales by state Explain) population
Does your company manufacture aerosol coatings for sale in California, or distribute aerosol coatings for sale in California?
I I Yes I I No
Do you wish to remain on the Air Resources Board's mailing list?
[] Yes
any Name:
ss:
et Person:



California Environmental Protection Agency

ARCHITECTURAL AND INDUSTRIAL MAINTENANCE COATINGS SURVEY - FORM II

Instructions for completing this form are in Pages 3.5 of the Survey Packet. O Air Resources Board

Confldentialt Yes . No		a Sales (Gallons)	Sold In Small	I liter or less					***				
Confidential	(1)	1990 Californ	Sold in Containers Sold in Small larger than I liter Containers										
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	(K)	VOC	Maximum Thinging (ed)		٠				•				
	(p)	001	of Material (g/l)	•	•								
	(2)		% Volume Solids		•								
	(11)	Resin	Code(s) (1-17)	;									
`	-		nology (1-4)					-			<u>.</u>		
	Special	Substrate/	Surface (Y or N)						4.				
(11)		Inter./	Coatings (I, E, D)								÷		
(1)	Number	٥	Orouped Coatlings									,	
(3)	VOC	Range	Code (1-15)										
(1)		Coatlog	. Code (1.0.31.0)										
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(Leave Blank) Company Code Number

Please Photocopy this Form if Necessary

Page of

If the Code for "Other" is entered into either (B) or (II), note the "other" as a comment in (N) below. .. If you answered "Yes" to (F), enter the specialty substrate or surface as a comment in (N) below

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valitornia Environmental Protection Agency

O AIF RESOURCES BOARD ARCHITECTURAL AND INDUSTRIAL MAINTENANCE COATINGS SURVEY - FORM II

Instructions for completing this form are in Pages 3.5 of the Surrey Packet.

Confidential? Yes 1 rio (M) 1990 California Sales (Gallons) 1 Containers 1 Guart Containers 1 Quart Ilier or less	
Sold in or larger	4
VOC Leas Water Leas Exempt (p/)	(
VOC Maximum Thinning (g/l)	
VOC of Material (p/)	
% Volume Solida	
(i.17) (i.17)	·
(G) Carrier Tech-nology (1:4)	
Special** Substrate Surface (Y or N)	
(l) Inter / Exter. (l, E, D)	
Number of Grouped Coailings	
(C) VOC Range Code (1:15)	
Coating* Code (1.0.31.0)	
Enty (A)	

If the Code for "Other" is entered into either (B) or (II), note the "other" as a comment in (N) below.

If you answered "Yes" to (P), enter the specialty substrate or surface as a comment in (N) below

back if additional space is necessary.			
om (A) and reporting item code (e.g. (B), (P) or (H)). Continue on the back if additional apace is necessary.	Entry #! ()	Entry#:()	Butry #: ()
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Please Photocopy this Form if Necessary

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OF Air Resources Board architectural and industrial maintenance coatings survey. Form ii Instructions for completing this form are in Pages 3.5 of the Survey Packed.

low low intermediate	11/2	ila Sales (Gallons)	in Containers Sold in Small er than I liter Containers	1 liter or less						-												
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	(p)	201	of Material	16.77			•			•						•						
	(E)		% Volume								•					-					ż	
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AIR RESQURCES BOARD 1102 Q STREET P.O. BOX 2815 SACRAMENTO, CA 95812



January 30, 1992

Architectural Coatings Joint Committee Members

Dear Sir/Madam:

Architectural Coating Thinning Study

I would like to thank you for your participation and for your comments during the joint study on architectural coating thinning practices in California. We greatly appreciated the cooperation displayed throughout the study and hope that the results are useful to you.

I have enclosed a copy of the technical paper on the "Field Investigation on Thinning Practices During the Application of Architectural Coatings in Selected Districts in California." If you have any questions, please call Chuck Beddow at (916) 324-6972.

Sincerely,

James J. Morgester Chief, Compliance Division

Enclosure



Technical Paper

91-CD-TP-2 December 1991

Field Investigation on Thinning Practices During the Application of Architectural Coatings in Selected Districts in California

by

Steven Giorgi James J. Morgester

California Air Resources Board, Compliance Division

In Cooperation with and the Assistance of the CAPCOA Enforcement Managers Committee, TRG Architectural Coating Committee, California Air Resources Board, Stationary Source Division, and USEPA Region IX

Field Investigation on Thinning Practices During the Application of Architectural Coatings in Selected Districts in California

Steven D. Giorgi James J. Morgester

Abstract

Based on the field inspections conducted during 1991 at over 85 different application sites, the California Air Resources Board (ARB) staff concluded that the current thinning practices of painting contractors applying architectural coatings in the districts studied did not result in a significant level of violations of volatile organic compounds (VOC) content limits. Painters indicated that 35% of the specialty architectural coatings observed were thinned with material containing VOC. However of the 52 specialty coatings observed, only 6% were in violation of the VOC content limit after being thinned. General architectural coatings were not usually thinned. In addition, only 2% of all coatings observed were in violation due to thinning.

INTRODUCTION:

At the request of the California Air Resources Board, Stationary Source Division, the staff of the Compliance Division initiated a field investigation on thinning practices during the application of architectural coatings. The investigation was conducted in cooperation with the joint committee representing the California Air Pollution Control Officers Association (CAPCOA) Enforcement Managers Committee, the Technical Review Group (TRG) Architectural Coatings Committee, ARB Stationary Source and Compliance Divisions, the California Department of Health Services Air and Industrial Hygiene Laboratory (AIHL), and the U.S. Environmental Protection Agency Region IX. The field investigation was completed with the assistance of local air pollution control district staff from the San Diego County Air Pollution Control District (SDAPCD), Bay Area Air Quality Management District (BAAQMD), Ventura County Air Pollution Control District (VCAPCD), and South Coast Air Quality Management District (SCAQMD).

The investigation consisted of field inspections at architectural coating application sites to determine if the thinning practices of painting contractors for certain specialty architectural coatings and for general architectural coatings resulted in violations of volatile organic compound (VOC) limits specified in local district regulations. Additionally, the study attempted to determine if painters and coating manufacturers were adhering to other portions of the district rules including the appropriate application or "end-use" of specialty coatings, coating labeling requirements, and "as formulated" coating VOC content limits. The study also identified other compliance issues which impact the architectural coating rules.

The architectural coating model rule was initially approved by the California Air Resources Board (ARB) in 1977. Subsequently, local air pollution control districts adopted rules and regulations based on the model

rule. The model rule or Suggested Control Measure (SCM), as it is referred to currently, was revised by the statewide Technical Review Group (TRG) in 1985. The SCM was reevaluated by the TRG and was approved by the ARB in 1989. The specialty architectural coating categories of concern were identified as solvent-borne coatings including: industrial maintenance coatings; lacquers; primers, sealers, and undercoaters (both quick-dry and general purpose); and enamels (both non-flat 250 grams per liter and quick-dry).

METHODOLOGY:

In order to complete this field study, the ARB Compliance Division staff initially prepared a written workplan and procedure in order to standardize sample and data collection. The workplan and procedure was evaluated and revised by the joint committee. This final workplan and procedure was provided to the staff of the individual districts who gathered the field data and samples for the study. The district inspectors conducted the inspections after reviewing the specific district architectural coating rule to be familiar with each standard and exemption in the rule. During the field study, Compliance Division staff coordinated laboratory services through AIHL, conducted the reduction of the field data, and prepared the study report.

INSPECTION SITES

A large number of potential coating sites were visited in order to locate a representative amount of sites where painting was actually occurring. Painting contractors do not typically operate at a fixed painting location identified by a district issued permit to operate while applying architectural coatings. The number of sites visited and number of samples collected varied among districts depending on the resources available to each district. These inspections were on an unannounced basis to reduce the potential for modifications to the painters' normal thinning practices. During the inspection period, one district dedicated a team of specific inspectors to this project while the other districts instructed their general field inspection staff to complete the inspections forms and collect samples as part of their day-to-day inspection routines.

In order to locate the coating application sites, several methods of identifying sources were utilized. One method used extensively by the BAAQMD included surveillance in areas of new construction activity. New construction activity was identified by district field inspectors who often recorded potential areas in the weeks preceding the survey. This method did not have a high frequency of success in locating sites where coating was occurring during the inspection; however, it did provide information on the types of painting which would be occurring during later construction. A second method involved inspections of governmental painting operations, i.e. cities, counties, school districts, state and federal agencies, etc. Both BAAQMD and SDAPCD inspectors visited school sites and governmental traffic coating application operations. Inspections were also conducted at industrial facilities which were likely to have industrial maintenance painting operations of existing structures and architectural components, i.e. military facilities, power plants. SDAPCD observed several painting

operations at its military facilities. Additionally, inspections were conducted at sites where painting was observed while conducting day-to-day inspections, e.g. a fire hydrant being repainted observed by a district inspector enroute to another inspection. Each district observed at least one painting site while conducting day-to-day inspections. Finally, after two weeks of the study, the BAAQMD contacted several larger painting contractors directly to identify the sites where painting would be occurring. The inspectors would then visit some of these sites. However, painting was often already completed prior to or not yet started during these site visits.

INSPECTION FORMS

When a potential site was visited, the initial section of the inspection forms was completed in order to track the number of sites located. An example of the inspection form used during the field study is included as Figure 1. The potential site was surveyed by looking for areas where painting may be occurring, for trucks belonging to painting contractors, or for portions of a construction or industrial site where paint buckets or spray equipment were present. A foreman or supervisor was often located to verify if coating was taking place anywhere within the site.

If coating was taking place, the remainder of the form was completed. These inspection forms provided data on coatings used, thinning rates and practices, application practices, and VOC content of coatings used in the architectural coating operation. The surface to be coated was noted and the architectural coating category was determined. The number and type of applicators, such as airless spray guns, etc. were noted. The coatings and other VOC containing materials in use were recorded and the applicable limits were verified. The coating labels were observed to record the manufacturer listed VOC content. The manufacturer's ID number, the date code identifying the date of manufacture, and any manufacturer mixing instructions were obtained. The painter was questioned if the coating was thinned. The inspectors verified what solvents were used for reduction and determined if the mixing ratio varied especially under different ambient conditions. The painter was questioned if liquid colorant had been added to the coating. The painters were also questioned concerning current and past thinning practices, and these statements were noted.

SAMPLING PROCEDURES

Each inspector took representative samples of "as applied" architectural coatings when the painter indicated that coating was thinned with VOC containing material. Samples of other specialty and general architectural coatings were also taken if the listed VOC content was greater than allowed, or if the inspector felt a sample was needed to verify compliance. The samples were collected as close to the application point as possible to minimize volatilization and spillage. The inspector recorded on the inspection form when the coating contained or was thinned with water or exempt solvents. Samples of each component for multi-component catalyzed coatings were collected, and the mix ratio in use was documented. Either VOC Data Sheets, Material Data Safety Sheets (MSDS) or Technical Specification Sheets were obtained for most of the samples taken. Coating

Figure 1 CALIFORNIA AIR RESOURCES BOARD INSPECTION CHECKLIST FORM FOR ARCHITECTURAL COATINGS

Inspector: Name of Contractor/Company:	Date: License #:
Contractor/Company:	License #:
	51
Business Address:	Pnone:
City	ZIP
Address of Job Site:	City
Representative:	Title:
1. Site Information: Residential	Commercial Industrial Other (Circle)
Is Coating taking place? Yes No	Any APCD Permit? #
Surface being Coated:	Interior or Exterior?
Painters Name: Ad	ddress:
Architectural Coating Category:	VOC Limit:
Records of Coating Usage? Yes No	Of Solvent Usage? Yes No
2. Sample Description: (Comp	plete one form for each Sample Taken)
Solvent borne: Water borne:	Exempt Solvent:
Sample Number:	Time Taken:
Manufacturer:	ld # :
Product / Brand Name & Description:	
Manufacturer Date Code:	Listed VOC Content:
Where was the coating purchased?	
Manufact. Recommended Thinner:	Amount Recommended:
Labeling Requirements met? Yes No	Container Size:
Describe Application Equipment:	
Amount Coating Used: per	Cleanup Material:
Describe Sampling Method and Location:	
s Thinner added? Yes No	Amount Added: per
s Liquid Colorant Added? Yes No	Amount Added: per
Why was Thinner Added?	•

3. Comments & Other Compliance Issues:

usage information was requested at the application site; however, in most instances observed, the information was not being kept by the painters.

Chain of custody policies were implemented for the collection and transfer of coating samples. All inspection documentation and samples taken were transferred to the identified enforcement contact at the district. This contact ensured that the samples were properly labeled, sealed, and stored in a secure cooler or refrigerator. Each sample and the associated inspection form was identified by a unique sample number. The samples were either driven directly or shipped to the Department of Health Services, Air and Industrial Hygiene Laboratory. At the lab, the samples were analyzed for percent volatiles, percent non-volatiles, density, percent water, and percent exempt solvent using EPA Test Methods 24 and 24A, and ARB Method 432. The VOC content of the applied coatings was compared to the VOC content claimed by the manufacturer either on the label or on the product data information sheets and to the VOC content required by the rule. Due to the limited data of usage available to the field inspectors, excess emissions could not be determined during the course of this study.

FIELD OBSERVATIONS:

It should be noted that thinning of architectural coatings with water was observed at many application sites. References to thinning made throughout this paper are referring to the use of VOC containing materials for thinning. The use of water for thinning does not impact the VOC content determination which is calculated on a "minus water and exempt solvent basis." Additionally, it should be noted that some differences exist in how the study was conducted by each district. These differences are identified in the field observations for each district.

SDAPCD FIELD OBSERVATIONS

SDAPCD conducted its field investigation between 6/7/91 and 8/9/91. The District inspectors observed 20 sites where architectural coating were observed being applied. SDAPCD completed inspection forms and collected coating samples at all sites where coating was observed. These sites included 9 commercial sites, 5 separate areas at military facilities, 3 schools, and 3 industrial facilities. Coating application methods observed included the use of brushes (noted at 14 sites), airless spray (11 sites), rollers (8 sites), high volume low pressure spray (1 site), air-assisted airless (1 site), and pump spray can (1 site). Comments from the painters at 3 sites indicated that VOC was used for thinning to facilitate or aid in spraying and to extend the pot-life of multi-component coatings. Open containers of VOC containing material were noted at 1 site.

The SDAPCD inspectors observed and collected 32 samples. Painters indicated that 5 of these samples had been thinned with VOC containing material. Of the collected coatings, 22 samples were specialty category architectural coatings while 10 of the samples were general architectural coatings. Additionally, one quality control sample was submitted for analysis. Fifteen (437) of the samples collected were solvent-borne (SB) coatings while the remainder were water-borne (WB) coatings.

BAAQMD FIELD OBSERVATIONS

The field investigation in the BAAQMD was conducted between 7/23/91 and 8/30/91. The BAAOMD's special team of inspectors visited 143 sites where coating was likely to be occurring. BAAQMD inspectors completed inspection forms for all sites visited, including sites where no coating was occurring and sites where non-specialty coatings were in use and samples were not collected. Residential sites accounted for 121 (86%) of the sites. remainder of the sites included 7 schools, 10 commercial sites, a hotel, church, hospital, and industrial facility. Of these sites only 61 (43%) were painting during the inspection. Out of the 61 sites that were coating, 40 (66%) of the sites were only using waterborne coatings while 21 (34%) were using solvent borne (SB) coatings. Several of the sites using solvent borne coatings were also applying waterborne coatings. The application methods observed included brushes (noted at 36 sites), airless spray (36 sites), rollers (42 sites), air-assisted airless spray (2 site), pump airless spray (1 site), air spray (1 site) and non-specified spray (3 sites). Comments from the painters at 7 of the sites that were using VOC containing material to thin, indicated that thinning with VOC was used to facilitate or aid in application due to the consistency of the coatings. The coatings were noted as being too thick or viscous to spray, brush, work with, or soak into the substrate. One contractor indicated that the builder required them to thin the coating when applied to wall-papered walls in the model homes. At least two contractors indicated that gun cleaning materials were added back to the coating containers as a thinner. Numerous comments were recorded which indicated that solvent-borne paints were not currently being used or being thinned by many architectural coating contractors.

The BAAQMD inspectors observed over 83 coatings being applied. Thirteen of the coatings were noted as being thinned with VOC containing material, however, 3 coatings at one site could not be sampled because not enough of the applied coating was available during the inspection. BAAQMD inspectors collected 15 specialty architectural coating samples and 2 general architectural coatings. In addition, BAAQMD inspectors collected duplicate/split samples which were analyzed by their own lab and also by AIHL. All duplicate sample results were compared and found to be within an acceptable range of deviation between two labs. Any results outside the acceptable limits were resolved to the satisfaction of both labs.

VCAPCD FIELD OBSERVATIONS

VCAPCD devoted a single inspector (part-time) to the project and identified two locations where painting was occurring. At least 4 coatings were observed in use. The inspection forms for both commercial sites indicated that water-borne primers and general coatings were in use. Thinning was not occurring, so samples were not collected. While the sites located in the VCAPCD contribute to the overall study findings, the two sites may not be statistically representative of the district as a whole.

SCAQMD FIELD OBSERVATIONS

The field investigation at the SCAQMD was initiated on 8/12/91 and continued until 9/20/91. Only two locations where painting was occurring were

identified by the SCAQMD inspectors during the investigation. Both coatings observed were specialty coatings. One sample was an exempt-solvent-borne traffic coating and the other was a water-borne primer. Neither sample was thinned by the operator. While the two samples collected in the SCAQMD contribute to the overall study findings, the two samples may not be statistically representative of the district as a whole.

RESULTS:

During the field study, architectural coatings were observed being applied at 85 different sites in the four districts. As shown is Table 1, over 121 coatings were observed being applied. A total of 49 samples of architectural coatings were analyzed by the laboratory as part of the study. These samples included all coatings identified as being thinned with VOC containing materials and various other specialty and general coatings. The coatings samples included 37 specialty coatings and 12 general coatings.

Table 1 Coatings Observed and Sampled

	Number of Coatings	Specialty Coatings	General Coatings	Thinned with VOC	# Not Thinned
Observed	121	52	69	18	103
Sampled	49	37	12	15	34

Only 15% (18) of the coatings observed in the field were identified by the painter as being thinned with VOC containing material. All of these thinned coatings analyzed were specialty coatings, including 1 water-borne specialty coating. Therefore, 35% (18) of all specialty coatings observed were identified as being thinned. Samples of 15 of these thinned coatings were analyzed by the laboratory.

Only 3 (2%) of the total number of coatings observed were thinned to a concentration which was in violation of the required VOC content limit. These three samples are listed in Table 2. For the purposes of this study, a sample was not considered in violation of the limit unless it exceeded the limit by greater than 10% in order to account for laboratory accuracy. These sample results also indicate that only 6% (3) of all specialty coatings observed were thinned in excess of the required VOC content limit.

Table 2 Thinned Coatings in Violation

Coating	Sample	SB /	VOC	Listed	Lab
Category	Number	WB	Limit	VOC g/1	VOC g/1
Primer Undercoater	ACBA - 005	SB	350	350	407
Stain	ACBA - 003	SB	350	-	780
Indust. Maint.	ACSD - 032	SB	420	420	468
SB = Solvent-borne	WB = Water-bo	rne			

Table 3 lists the samples results for the speciality coatings which were identified as being thinned with VOC containing material and were in compliance with the VOC limits in the rule. Sample ACBA-016 was identified as a water-borne coating which was thinned with gun cleaning solvents.

Table 3
Thinned Coatings in Compliance

Coating Category	Sample Number	SB / WB	VOC Limit	Listed VOC g/1	Lab VOC g/l
Indust. Maint. Indust. Maint. Trim & Rails Indust. Maint. Primer Rails Lacquer Quick Dry Sealer Primer Primer Primer Sealer - Walls Primer Undercoater Primer Undercoater - Walls Primer Undercoater - Walls Primer Undercoater Stain - Semi-Transparent	ACSD - 010 ACSD - 022 ACSD - 024 ACBA - 015 ACSD - 020 ACBA - 011 ACBA - 010 ACBA - 011 ACBA - 012 ACBA - 013 ACBA - 014 ACBA - 016	SB SB SB SB SB SB SB SB SB SB SB	420 420 420 680 525 350 350 350 350 350 350	420 420 420 680 - 140 350 - 350 350 350 350	430 311 407 619 329 232 294 337 336 334 261 310
CD C. T					

SB = Solvent-borne

WB = Water-borne

Table 4 lists the 6 (5%) samples which were not thinned by the painter and exceeded the VOC content limit by greater than 10%. It should be noted that samples ACSD-002 and ACSD-005 showed VOC contents in excess of the listed VOC content. The laboratory rechecked the analysis and are satisfied with the results. The inspection forms were reviewed and it was confirmed that the painter stated that no thinning occurred.

Table 4 Non-Thinned Coatings in Violation

Coating	Sample	SB /	VOC	Listed	Lab
Category	Number	WB	Limit	VOC g/l	VOC g/1
Bond Breakers Indust. Maint. Floor Sanding Sealer Stain - Semi-Trans. Lacquer General - Metal Handrails General - Int. Door Frame	ACSD - 012	SB	350	710	715
	ACSD - 002	WB	420	200	729
	ACBA - 002	SB	550	680	684
	ACBA - 017	SB	350	-	780
	ACBA - 008	SB	250	420	416
	ACSD - 005	SB	250	234	384

SB = Solvent-borne

WB = Water-borne

Two types of violations are noted within Table 4. Several violations appear to have resulted from the application of coatings formulated for a specific specialty category which were applied by the painter to surfaces outside its

designated end-use. For example, Industrial Maintenance coatings were used for metal handrails and interior door trim at residential sites. Additionally, other applications of Industrial Maintenance coatings should be reviewed for the appropriateness of the end-use including the use on the walls of a guard shack, fire hydrant, metal doors at commercial facility, and floor at a commercial facility. Several violations within Table 4 resulted from coatings applied which did not meet the limits set for the specialty category. For example, a high VOC content Bond Breaker and a Stain (semi-transparent lacquer) were observed in use and the laboratory results indicated the VOC content exceeded the limit.

Table 5 lists the coating samples which were not thinned by the painter and which tested in compliance with the VOC content limits identified by the district.

Table 5 Non-Thinned Coatings in Compliance

		-	•		
Coating Category	Sample Number	SB / WB	VOC Limit	Listed VOC g/1	Lab VOC g/1
Graphic Arts Indust. Maint. Floor Indust. Maint. Fire Hydrant Indust. Maint. Metal Walls Indust. Maint. Dock & Rail Indust. Maint. Metal Doors Indust. Maint. Lacquer Lacquer Sanding Sealer Quick Dry Enamel Ext. Flat Quick Dry Enamel Ext. Trim Primer - Wood Beams Primer - Pipes & Valves Primer - Ext. Wood Sanding Sealer Quick Dry Stain - Opaque - Ext. Stain - Opaque Ext. Traffic Coatings General - Wood Door & Trim General - Ext. Flat Wall General - Int/Ext Flat General - Int. Doors General - Int. Flat General - Int. Wood Trim General - Int. Wood Trim General - Int. /Ext. Wall General - Int./Ext. Trim	ACSD - 011 ACSD - 001 ACSD - 013 ACSD - 016 ACSD - 018 ACSD - 026 ACSD - 033 ACBA - 006 ACBA - 007 ACSD - 019 ACSD - 019 ACSD - 003 ACSD - 007 ACSD - 015 ACSD - 017 ACBA - 009 ACSD - 017 ACBA - 009 ACSD - 014 ACSD - 021 ACSD - 023 ACSD - 028 ACSD - 028 ACSD - 029 ACSD - 030 ACSD - 031	SB SB SB SB SB SB SB SB SB SB SB SB SB S	500 420 420 420 420 420 420 680 400 350 350 350 350 250 250 250 250 250 250 250	420 200 420 250 390 335 297 680 250 391 350 235 554 133 250 249 250 250 250 250 250 250 250 250 250 250	381 211 432 197 357 363 203 663 660 138 402 358 279 79 544 179 125 250 258 10 159 143 245 190 138 125 144
		WB	250	250	274

SB = Solvent-borne

WB = Water-borne

The laboratory results from this study showed a large percentage of specialty architectural coatings used in the districts studied which meet or have a lower VOC content than required by the rule. In addition, the laboratory results from this limited study tended to show that the VOC content of the water-borne coatings, both specialty and general category coatings, were much lower than the required VOC content and were often much lower than the level identified on the label. These results show that water-borne formulations have been developed and are in use which can meet lower VOC limits on a "minus water and exempt solvent" basis.

Initial lab results indicated the presence of exempt solvent in 28 out of the 49 samples including water-borne coatings. However, the Material Safety Data Sheets for the coatings did not indicate that either methylene chloride (DCM) or 1,1,1 trichloroethane (TCA) were present in the coatings. inspection forms did not indicate that the coatings contained exempt solvents. Additionally, architectural coatings, except for traffic coatings, had not previously been noted to be frequently formulated with exempt solvents due to various concerns, including substrate incompatibility, worker exposure, and waste disposal. Samples were re-run using both BAAQMD method and ARB method 432. No exempt solvent was observed upon re-analysis. A peak was observed during the gas chromatographic analysis which was close to the retention time of TCA. This observed peak may have been incorrectly identified as TCA during the initial analysis and is suspected to be an alcohol. In addition, the BAAQMD duplicate/split samples results were reviewed. Both labs indicated that they were satisfied that no exempt solvents were present in the samples compared.

A second test method concern involved the addition of colorants to coatings. The current architectural coating rules exclude the contribution to the VOC content from colorants. The test methods used to determine the VOC content of coatings do not separate out the colorants from the applied coatings. The use of powder colorants would increase the solid content of a coating and therefore decrease the VOC content. If a liquid colorant containing VOC were used, the VOC content of the coating may increase. Therefore, data was collected on the addition of liquid colorants. Liquid colorants were not identified as being added to many of the coatings observed in the field. The coatings which were noted as having liquid colorant added indicated that only ounces or drops per 5 gallons was typically added. No samples identified as having liquid colorants added were found to be in violation of the VOC content limits in the rules. The limited data collected during the study indicated that the VOC from colorants should be included during the VOC determination of applied coatings.

A number of sites were noted where phenyl mercury biocide added to coatings for mildew control. It is not clear if these materials would have any impact on the VOC content of the coating in the quantities added. Samples were not usually taken because the coatings were water-borne coatings which were not thinned with VOC containing material.

Several findings were identified with regard to labeling requirements during the field study. The VOC content identified on labels often only indicated

that the coating was less than a numerical limit, i.e. < 250 g/l. The VOC content for many of the coatings tested was significantly lower than the label indicated. Additionally, one label for a sanding sealer stated that the VOC content was less than 680 g/l while the limit was 550 g/l. The label for at least one coating observed in the field indicated that the coating did not comply with the district architectural coating rule and was not to be used for that purpose.

Both water and VOC containing clean-up materials were observed at the application sites. A large number of sites identified a wide range of disposal methods for the water used to clean-up the application equipment and containers. These methods ranged from discarding liquid containing solids, water, and VOC onto the ground; to disposing into wastewater/sewage treatment plumbing; to sealing the liquid into containers which are collected by a hazardous materials hauling from the contractor's shop. The districts attempted to refer waste disposal issues to local water/wastewater districts, the Department of Health Services, and the Regional Water Quality Control Board when appropriate. The sites using VOC containing clean-up materials indicated that the liquid was collected into containers and either reused or recycled or used to thin coatings.

CONCLUSIONS:

The results of the field investigation showed that the current thinning practices of painting contractors applying architectural coatings within the districts studied did not result in a substantial level of violations of VOC content limits. One-third of the specialty architectural coatings observed were thinned with material containing VOC while general architectural coatings were not usually thinned. Only 6% of all specialty coatings observed were thinned in excess of the required VOC content limit. A total of only 2% of all architectural coatings were in violation due to thinning.

The field study also tended to show that a larger percentage of violations resulted from the application of coatings which exceeded the VOC content limit without being thinned. This appeared to be a combination of coatings being applied which did not meet the limits set for the specialty category and coatings formulated for a specific specialty category which were applied by the painter to surfaces outside its designated end-use.

The laboratory results from this study showed a large percentage of specialty architectural coatings used in the districts studied which meet or have a lower VOC content than required by the rule. This shows that complying specialty coatings are being applied successfully by the applicator without thinning.

The laboratory results from this limited study tended to show that the VOC content of the water-borne coatings, both specialty and general category coatings, were much lower than the required VOC content and were often much lower than the level identified on the label. These results show it is possible for water-borne formulations to meet low VOC limits which are "minus water and exempt solvent" based.

Additionally, the limited data obtained during the study tends to support inclusion of colorants during the determination of VOC.

ACKNOWLEDGMENTS:

The local districts which fully participated in this study should be commended for their effort and professionalism in conducting this study. The effort of several district staff members deserve special recognition and thanks, including Randy Smith of SDAPCD and both Kelly Wee and Steve Chin of BAAQMD. This study required a significant amount of time, field staff, and laboratory resources to evaluate the impact of thinning of architectural coatings in the field. Additionally, credit should be given to the painting contractors inspected who for the most part demonstrated an awareness of air pollution regulations, were successfully applying complying coatings, and displayed cooperation during this field study.

New generation of latex gloss enamels: how good are they?

by WALT GOZDAN **Technical Director** The Rohm and Haas Paint Quality Institute

erhaps more than any other type of paint, latex gloss enamels are proof of the advances that paint technology has made in recent years.

As recently as a decade ago, these coatings (which are sometimes called acrylic enamels) were something of an also-ran among paint products.

Although they offered the same benefits as all water-based paints, including easy cleanup, fast recoat and lower-odor application, they came up short in other respects.

In terms of application, for example, the earlier latex gloss enamels did not match the flow, leveling, and film build of their alkyd counterparts.

They did not do well in terms of block resistance and stain resistance.

And in terms of gloss, most of these products could produce a very good semi-gloss, but not a true high gloss appearance.

The impact of new technology

But that was then, and this is now. Within the past few years, two phenomena have combined to significantly improve latex gloss enamels rheology modifiers and advanced binder technology.

The scientific progress they represent is impressive. But your customers are more likely to appreciate the new latex

gloss enamels for their improved application, appearance and durability characteristics.

Application improvements: In order to achieve a uniform, high gloss finish, it was necessary for paint manufacturers to enhance the application properties of latex gloss enamels - specifically their flow, leveling, and film build. Thanks to the advent of rheology modifiers, they have been able to do so.

(Rheology additives give good flow and leveling during application but contribute to sag resistance soon after the paint has been applied. They do this by providing high viscosity as the paint is being worked by a brush or roller and low viscosity when the paint is no longer being worked.)

Flow in the new latex gloss enamels is now comparable to that of alkyd formulations. In fact, from the standpoint of brush drag, it is hard to tell the difference between the new gloss enamels and alkyds. The excellent flow and increased film build of today's latex gloss enamels make them easier to work with and give them better coverage than ever before.

Rheology modifiers have also improved the leveling of the new latex gloss enamels which helps create a smooth, uniform painted surface with a minimum of brush marks.

Improved flow and leveling, together

with the thicker film build of this new generation of latex gloss enamels, has allowed uniform, high gloss finishes with good hiding to become a reality.

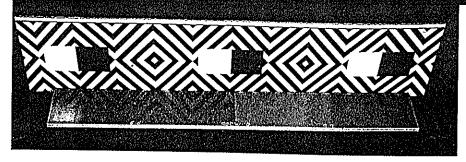
Better exterior performance: When rheology modifiers are responsible for the improved application characteristics of latex gloss enamels, it is the developments in binder technology that have improved the exterior durability of these paints.

Especially when compared with their alkyd counterparts, today's latex gloss enamels offer outstanding gloss retention, good color retention and better resistance to dirt and mildew.

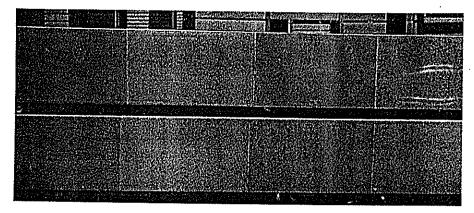
Although it is true that alkyds may exhibit a somewhat higher initial gloss, latex gloss enamels retain their gloss for a much longer period of time. Naturally, this means that surfaces coated with top quality latex gloss enamels will not need frequent repainting - a benefit that is important to stress to your customers.

Color retention is another area in which latex gloss enamels do well. Compared with alkyds, these paints have significantly better fade resistance and will not embrittle over time.

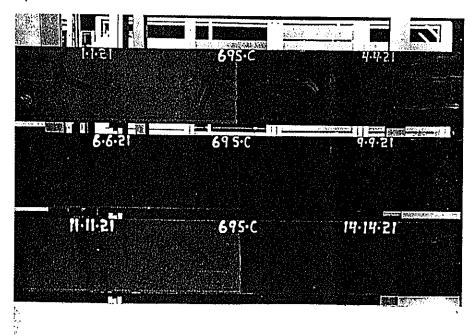
It is also rare for latex gloss enamel to discolor from dirt buildup or mildew. That is because latex products do not provide a hospitable environment for mildew growth, and dirt has difficulty penetrating the hard, hydrophobic



Gloss and color retention of high-gloss enamels: Exposed for three years, this panel shows a latex acrylic gloss enamel on the left and an alkyd gloss enamel on the right. The panel was photographed against a patterned background to provide a means of judging and comparing gloss levels. The acrylic enamel shows excellent gloss and color retention. The alkyd enamel exhibits color fading and a dramatic reduction in gloss.



Durability of high gloss enamels: Two coats of test paint (alkyd on the far left and two right sides; acrylic on the second from the left) were applied over chalked alkyd paint. After three years at a south vertical exposure, the acrylic high gloss enamels are in excellent condition with no dirt pickup or mildew. The alkyd paint on the lower left panel has multiple cracks. All three alkyd paints on both panels exhibit dirt collection and mildew.



Tint retention of semigloss enamels: Two coats of each test paint were applied over primed cedar panels and exposed for 17 years. Alkyd paints were on the left; and acrylic latex paints were on the right. Note the pronounced color fading and heavy chalking of the left side of the panels. Acrylic paints show very little color fade.

surface of latex gloss enamels.

In view of the excellent gloss and color retention of latex gloss enamels — and their dirt- and mildew-resistance — latex gloss enamel paints are an excellent choice for use on trim areas. These are important points to make to customers concerned about the long-term appearance of their homes.

Interior applications: The improved flow, leveling and film build of the new generation of latex gloss enamels make them a good choice for interior painting, too. But there are other reasons to favor today's interior gloss enamels — namely, better block resistance and washability.

The new latex gloss enamels reach maximum hardness quickly, which is needed for good block resistance. This property is particularly useful where opposing surfaces touch, such as on door and window frames.

Stain removal and washability are important attributes for interior gloss paints, since they are frequently applied in demanding, high-traffic areas like kitchens and bathrooms.

The new latex gloss enamels easily tolerate energetic scrubbing and washing without suffering damage. Even stubborn stains can usually be removed with a conventional cleaner.

Continuing improvements

As remarkable as the recent advances in latex gloss enamels have been, scientists at the Paint Quality Institute and elsewhere are always striving to improve them. Areas that have been receiving a lot of attention are "open time" and "wet-edge" time, which are needed to produce a uniform appearance when painting a large surface such as a door.

Open time has always been a strong suit for alkyd paints. But research is now underway to develop binder technology that will improve the open time of latex gloss enamels so that they can be easily applied and produce the outstanding appearance expected of a high gloss finish.

As a knowledgeable painting contractor, it is important that you tell your customers about the improvements in today's latex gloss enamels.

By doing so, you can help your customers make a more informed choice when they are looking for a quality high gloss paint.

High-Solids Coatings For Steel Close the Performance Gap

By Linda S. Salem, Director of Research and Development; and Robert J. Klepser, Group Leader/Research and Development, Carboline Co., St. Louis.

UMEROUS METHODS exist in coatings technology for compliance with volatile organic compound regulations as defined by the Environmental Protection Agency (EPA). These methods include water-borne technology, use of exempt solvents and high-solids conventional coatings technology. This article will address high-solids conventional coatings technology for the protection of steel as a means of compliance.

The federal government first acted on a growing health problem caused by various air pollutants by passing a bill in 1955 to study the problem. The Clean Air Act of 1963 proved to be the first real action resulting from these studies. By 1970, the EPA was formed and given authority to establish control standards, designate regional control centers and set timetables for compliance. The amended Clean Air Act of 1977 required all states to be responsible for regulations to control volatile organic emissions in areas that have not attained the National Ambient Air Ouality Standard for ozone.

The Clean Air Act Reauthorization/ Amendments of 1990 now provide EPA with more detailed direction on how to reach goals of improved air quality. The EPA can now address issues of hazardous air pollutants, atmospheric ozone and volatile organic compounds (VOCs) on a national basis.

In addition to the Clean Air Act, other regulations the coatings supplier is confronted with in dealing with the development and use of products include the Clean Water Acts, OSHA, TOSCA, SARA and RCRA. The coatings supplier's current goal is to develop VOCcompliant products, provide corrosion protection and the required aesthetics, be economical and applicable with readily available equipment, be safe to the applicator and environment, and provide confidence to the user or specifier that it can achieve all of these specifications.

Coatings

The industry has been concerned that many means of achieving VOC compliance fell short of achieving their primary purpose of corrosion protection, or have other limitations such as application characteristics. However, with the growth in coatings technology, proven VOC-compliant products have been available for six years. Organizations such as the Steel Structures Painting Council and Federal Highway Administration have acknowledged the capabilities of these coatings.

Because the high performance coatings industry has gravitated to certain generic types of coatings, initial development of low-VOC coatings also centered around proven coatings such as inorganic zinc primers, catalyzed epoxies and polyurethanes.

Zinc-rich primers provide maximum corrosion protection and are the basis for many high-performance coating systems. Compliant zinc-rich primer technologies available include high-solids inorganic solvent-based, water-based and high-solids organic. Table I is a comparison of properties of an inorganic solvent-based zinc primer having a VOC of 2.2 lbs./gal. with a current industry standard having a VOC of 4.3 lbs./gal. After 2,000 hours of American Society for Testing and Materials (ASTM) B117 salt fog testing, the VOC version performed equally. Table II il-

Table I	. Inorganic	Zinc Primer
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Table I. Inorganic Zinc Primer		
Property'	Standard Version	VOC Version
Coverage, mil sq.ft.	1000	1200
VOC, lbs./gal.	4.3	2.2
Pot Life, hours	8	6
Dry to Handle, hours	1/2	1 "
ASTM B117, 2000 hours	No rust	No rust
Adhesion, psi	262	283

Table II. Epoxy Zinc Primer

Table II. Lpoxy Zille I Illier		
<u>Property</u>	Standard Version	VOC Version
Solids by volume, %	51	64
VOC, Ibs./gal.	3.5	2.5
PVC, %	60	59
Pot Life, hours	6	4
Dry to Handle, hours	1	2
ASTM B117, 2000 hours	Slight rust	Slight rust
Adhesion, psi	458	516

lustrates a comparison of organic epoxy zinc-rich primers. Again, the VOC version performed as well as the others.

Epoxy coatings have found use in a variety of conditions, ranging from OEM applications to immersion. Because of their widespread use as primers, intermediate coats and topcoats, it was important to develop low-VOC counterparts.

Table III shows comparisons between a low-VOC epoxy primer and its conventional epoxy primer counterpart. The low-VOC primer is supplied as a 77 percent solids by volume coating with 1.57 lbs./gal. volatile organic content. After 1000 hours of ASTM B117 salt fog and water fog testing, the corrosion protection and adhesion offered by the low-VOC primer proved superior to the conventional counterpart.

Similarly, high-solids VOC topcoats are capable of equal or superior performance to that of conventional lowersolids epoxies. Table IV depicts Topcoat A supplied as 75 percent solids by volume with a 1.78 lbs./gal. VOC. A conventional high-build epoxy topcoat is supplied as a 59 percent solids by volume coating with 2.74 lbs./gal. VOC. The performance of a system utilizing the previously mentioned primer (Table III) and these topcoats, is shown in Table V. The low-VOC system provided corrosion protection equal to the conventional system.

Low-VOC urethanes have been developed with excellent weathering, adhesion, gloss and color retention, and chemical resistance. Table VI compares various properties of a VOC version with a standard. The VOC version is superior in QUV accelerated weathering and equivalent in other characteristics. Figure 1 further illustrates weathering performance, comparing a low-VOC standard and premium types with the non-compliant product.

Application

Early attempts at developing low-VOC coatings were simplistic — merely removing solvent. The resulting products required heat for viscosity reduction or required non-standard application equipment. The low-VOC coatings presented here clearly illustrate the availability of products that can be applied with existing equipment. While these products can be applied with conventional and airless spray equipment, some user education may be necessary. With the higher solids of low-VOC products, more film is deposited with

Table III. Epoxy Primer: Low-VOC Versus Conventional

	Low VOC Epoxy Primer	Conventional Epoxy Primer
VOC, as Supplied VOC, as Applied Solids By Volume	1.62 lbs./gal. 2.08 lbs./gal. 77%	3.54 lbs./gal. 4.31 lbs./gal. 50%
Salt Fog ASTM B117 (1000 hours)	Rust in Scribe Moderate Undercutting	Rust in Scribe Moderate Undercutting Slight Rust
Adhesion Water Fog 1000 hours	750 psi Rust in Scribe	425 psi Rust in Scribe #8F Blisters, 9R Rust in Plane

Table IV. Epoxy Topcoat: Low-VOC Versus Conventional

	Low VOC Epoxy Topcoat	Conventional Epoxy Epoxy Topcoat
Solids By Volume	75%	59%
VOC, as Supplied	1.78 lbs./gal.	2.74 les./gal.
VOC, as Applied	2.08 lbs./gal.	3.67 lbs./gal.

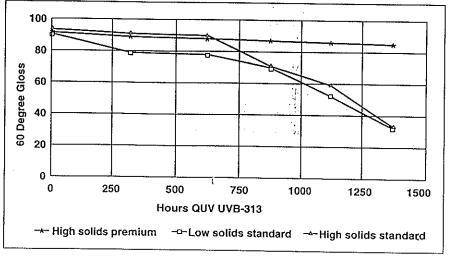
Table V. Epoxy System Performance

$(x,y) \in \mathcal{X}_{(x,y)}$	Low VOC Epoxy System	Conventional Epoxy System
System:		•
Primer	3 Mils	3 Mils
Topcoat	5 Mils	5 Mils
Adhesion	952 psi	346 psi
Abrasion	119 mg	120 mg
Water Fog (1000 Hours)	Rust in Scribe	Rust in Scribe
	#4 Blisters	#6F Blisters
Salt Fog (1000 Hours)	Rust in Scribe	Rust in Scribe
• •	Slight Undercutting	Edge Rust

Table VI. Urethane Finish

Property	Standard Version	VOC Version
Solids by volume, %	48	65
VOC, Ibs./gal.	4.0	2.5
PVC, %	20	22
Pot Life, hours	4-6	4-6
Dry to Handle, hours	3	4
QUV B Bulb 1250 hours	45% gloss ret.	95% gloss ret.
Adhesion, psi	200	275

Figure 1. Accelerated weathering of urethane topcoats.



each pass of the spray gun. This necessitates altering application techniques. Also, with higher-solids, the user will observe slightly different flow characteristics which may appear as a slight orange peel effect.

Safe Usage

There are positive effects in the use of low-VOC coatings. The solvent in coatings reacts photochemically with sunlight to generate ozone, which is responsible for smog. The availability and use of low-VOC coatings will reduce the

level of solvent that can generate ozone in the atmosphere.

On a micro level, worker exposure to solvent is greatly reduced with the use of high-solids coatings. Although conventional coatings can be applied in a safe manner, with solvent levels well under threshold limit values under OSHA regulations, lowering the solvent levels in coatings results in safer products. In addition, the coatings supplier would be wise to avoid the use of any suspect solvent or chemical such as chlorinated solvents and silica.

Economics

The availability and acceptance of low-VOC coatings have been aided by the economic advantages presented to the user. Because the solids by volume are higher than in conventional coatings, the cost-per-gallon is generally higher. However, the coverage rates per gallon are also higher. This results in the cost-per-square-foot of high-solids coatings being less than or equal to conventional coatings. An additional benefit would be lower cost per square foot per service life.

There are additional economic benefits that are accrued with the use of high-solids coatings. For example, if a user typically inventories 500 gallons of a conventional epoxy coating with solids by volume of 50 percent, his inventories of a 75 percent solids by volume will drop to 333 gallons — a 33 percent reduction.

Storage space may be reduced by that amount or additional materials stored in the space. The number of pails to handle and unload are reduced by 33 percent. Similarly reduced are the volume of coatings to mix and the required time.

The density of high-solids coatings is generally equal to or only slightly higher than conventional coatings. The reduction in volume also translates to a reduction in weight, which provides the user with significant savings in freight.

Confidence

The acceptance rate of low-VOC coatings has been excellent, due primarily to the confidence the user or specifier has in the products.

The performance and ease of use of inorganic zinc primers, epoxy primers and topcoats, and polyurethane topcoats have been established by 10 to 25 years of field use and acceptance of these generic types. Low-VOC counterparts of these generic types are being readily accepted because of the familiarity of the generic type and their performance.

The acceptance rate of these products is enhanced because there are no hurdles or outlay of capital to make the change to low-VOC coatings. Also, the ability to use current application equipment has made the transition from conventional to low-VOC coatings a simple one.

The relative safeness of these products provide the user with confidence. They can be confident of providing a compliant coating that is safe for the applicator and the environment.

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EVA Maintains Paint Properties, Lowers VOC

By Bill Currie
Technical Manager, Nacan Products Ltd.,
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substantially reduce the level of VOC contributed to the environment by water-based paints, and it can be done without adversely affecting the properties of the paints. In fact, some properties, notably scrubability and odor, are improved.

While the fact that there are trace amounts of several VOC elements in paint formulations must be accepted, we can honestly say that no solvents have been used in new formulations based on the technology described in this article.

The push to solvent-free began in Europe, where Germany and Scandinavia currently lead the way. The leading technology in this area is ethylene vinyl acetate and acrylated ethylene vinyl acetate. It has been in use commercially for several years in Europe, where it was originally developed.

To appreciate the advantages of this technology, the chemistry of ethylene vinyl acetate terpolymers should be examined and then formulations evaluated based on an EVA polymer versus conventional coalesced technology, versus conventional solvent-free binder technology, and versus commercially available solvent-free paint.

The major components of today's water-based paints are pigments, tinting systems, rheology modifiers, binders and — the main contributors of VOCs — coalescing solvents and glycols. Typical coalescing solvents in current use are 2,2,4-trimethyl pentane diol-1,3 mono isobutyrate; diethylene glycol monobutyl ether acetate; and dipropylene glycol nbutyl ether. The glycol is typically propylene glycol.

The objective of switching to ethylene vinyl acetate terpolymers is the

removal of the volatile organic components of a water-based paint formulation, specifically the coalescing solvent and the glycols, to achieve a solvent-free, low-odor paint.

The VOC Problem

Looking at a typical contemporary semi-gloss formula, it can be estimated that the VOC contribution from the components is slightly more than 4 percent (coalescent = 1 percent, glycol = 3 percent, other components ± 0.1 percent). This total depends on the type of thickener used, as some thickeners contain high levels of VOCs. But the 4 percent estimate is

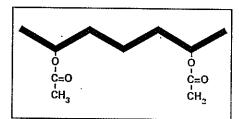


FIGURE 1, EVA.

based on the newer solvent-free thickeners.

Judging by the quantity of waterbased trade sales paints sold in a year, it appears that the contribution of volatile organics may well reach over a 100 million pounds in North America. The use of EVA terpolymers offers an effective, performance-enhancing solution to this dilemma.

The Chemistry of EVA

In a standard solvent-containing paint, the use of a coalescing solvent allows a high-Tg, harder polymer which will film-form at a lower temperature with the aid of the coalescent which, once it evaporates, will yield a durable, non-tacky film.

When formulating a low-odor, solvent-free paint, the binder is required to form a film at low temperature without coalescent, as well as dry to a tough, durable, non-tacky finish.

This is done through the correct selection of monomers and the judicious positioning of these monomers within the polymer's morphology. The polymers discussed here are based on three monomers: vinyl acetate, ethylene and an acrylic monomer.

Vinyl acetate allows for greater film integration at lower film-forming temperatures by contributing to hydroplasticization — the use of water to act in the same way in part as a coalescing solvent.

Ethylene, due to its low Tg of -80°C and its unique mode of internal plasticization, is responsible for the polymer displaying softness without tack — a desirable property.

The acrylic monomer allows for a reduction in vinyl acetate content for improved hydrolysis resistance.

The process by which in-chain or internal plasticization leads to flexibility is shown in Figure 1. Flexibility is achieved through the reduction of steric hindrance, with the ethylene groups acting as spacers between vinyl acetate and acrylic groups.

The three monomers are polymerized as a surfactant-stabilized, water-based emulsion at 55 percent solids level, in such a way as to ensure maximum performance in a water-based paint. This reaction is carried out in specialized high-pressure reactors due to the extremely high pressure of ethylene at normal polymerization temperatures.

It is because of this high pressure that the acrylated EVA polymers are referred to as pressure polymers when compared to products such as acrylics and vinyl acrylics, which are produced at much lower pressure and are referred to as conventional or atmospheric polymers. The molecular weight of the pressure polymers is higher than in conventional polymers, which builds greater toughness in the resultant film.

The original technology, developed in Europe, contained vinyl chloride. Due to restrictions on chloride ions in the effluent of paint plants in Europe, this technology was modified to the acrylated EVA. It was later successfully transferred to North America, where it is now manufactured as Vinamul 3692, and is commercially available through Nacan Products Ltd. in Canada.

Properties of the acrylated EVA polymer as used in our evaluations are as follows:

- •solids 55%
- •viscosity, cps 2500-3500
- pH 4.5 5.5
- •Tg, °C 12
- •MFFT, °C <1
- •particle size, microns 0.4

Formulations

Several starting formulas have been developed, three of which are used for evaluations: a 27 percent PVC semi-gloss; a 37 percent PVC eggshell; and a 62 percent PVC flat.

These solvent-free formulations are distinctly different from the more familiar solvent-containing formulations, as they possess no coalescing solvent and no glycol.

For pH adjustment, an inorganic alkali-potassium hydroxide is used. This chemical has been chosen because amino methyl propanol, a commonly used neutralizing/buffering agent, is considered a VOC, according to EPA test method No. 24 in the U.S. and current ECO logo standards and the proposed Enviro Choice Standards in Canada.

Use of potassium hydroxide requires care and attention. It is a strong alkali and safe handling procedures must be followed. The method of addition must also be carefully controlled in order not to shock the system and cause lumping. The thickener and the alkali are added in the grind stage and not in the letdown as is more common in solvent-containing paint.

As far as paint performance goes, an evaluation was conducted of our suggested formula versus the same formula using amino methyl propanol in place of potassium hydroxide as the neutralizing agent, and no loss was found in scrubability or other properties.

The thickeners used for rheological modification are hydrophobically

TABLE I. Solvent-Free Semi-Gloss (SF004C)

Water	300.0
BYK 156 Dispersant	4.0
BYK 034 Defoamer	2.0
Caustic Potash (45 percent)	4.0
Titanox 2020	300.0
ASP 170	50.0
Polyphobe 108	25.0

Disperse 5 - 6 Hegman

•	
Water	95.0
Rexol 45/407	- 6.0
Vinamul 3692	550.0
Kathon LX	0.5
BYK 034	2.0

1387.5

PVC — 27 percent Weight Solids — 49.9 percent Volume Solids — 35.9 percent Pounds per Imperial Gallon — 12.83 Pounds per U.S. Gallon — 10.65 60° Gloss — 54

TABLE II. Solvent-Free Eggshell (SF005B)

Water	320.0
& Colloid 226-35	6.0
BYK 034 Defoamer	2.1
Caustic Potash (45 percent)	4.0
Titanox 2020	257.7
Calcium Carbonate (3 micron)	107.4
∵ASP 170	64.4
Polyphobe 108	25.0

Disperse 5 - 6 Hegman

Water Rexol 45/407 Vinamul 3692 Kathon LX RVK 034	90.0 5.4 449.5 0.5
BYK 034	<u>2.0</u> 1387.5

PVC — 37 percent
Weight Solids — 51.9 percent
Volume Solids — 36.0 percent
Pounds per Imperial Gallon — 13.34
Pounds per U.S. Gallon — 11.11
60° Gloss — 10

modified ethoxylated urethanes-alkali swellable thickeners (HEURASE). While it is not uncommon to find these thickeners in coalescent-containing formulas, they were used because they contain no solvents and give the desired rheological properties. The potassium hydroxide also helps to swell these thickeners and optimize their performance.

Suggested Formulations

Formula 1 — The 27 percent PVC semi-gloss paint contains 49.9 percent weight solids and 35.9 percent volume solids: no coalescent, no glycol, potassium hydroxide for pH adjustment, and HEURASE thicken-

ers added during the grind. See Table I

Formula 2 — The 37 percent PVC eggshell paint contains 51.9 percent weight solids and 36 percent volume solids: no solvents. The 45 percent potassium hydroxide is put in early to dilute it down before the pigments and thickener are added. See Table II

Formula 3 - The 62 percent PVC flat paint contains 54 percent weight solids and 33.2 percent volume solids: no solvents. This formula does not contain a HEURASE thickener. Instead, a solvent-free hydrophobically modified ethoxylated urethane (HEUR) thickener is added in the letdown, and a cellulosic thickener is added in the grind — similar to a coalescent-containing system using a blend of cellulosic and associative thickeners. See Table III.

These are suggested starting formulations and should be laboratory evaluated before commercialization.

Evaluations

The three solvent-free formulations suggested here, containing Vinamul 3692, were all evaluated in our laboratory versus a high-scrub coalesced vinyl acrylic, versus competitive commercially available solvent-free acrylic and vinyl-acrylic binders, and versus commercially available solvent-free paints.

The acrylated EVA technology in the solvent-free formulations gave performance properties equivalent to or better than the other products evaluated in the following tests —

TABLE III. Solvent-Free Flat (SF003)

Water		400.0
Colloid 226-35		· 4.0
Colloid 643		2.0
Natrosol 250 HR		5.5
ASP-400 Clay	•	105.0
Titanox 2020		230.0
Omyacarb 6		278.0

Disperse 2 - 3 Hegman

Water	120.0
Rexol 25/9	3.5
Vinamul 3692	260.0
Acrysol RM 2020	20.0
Colloid 643	2.5
Kathon LX	0.5
Adjust to pH 8.5 with	
50 percent KOH	

1432.0

PVC — 62 percent Weight Solids — 54.0 percent Volume Solids — 33.2 percent Pounds per Imperial Gallon — 14.35 Pounds per U.S. Gallon — 11.95 specifically in scrubability, durability, and gloss stability in a semi-gloss paint.

Figure 2 shows scrub resistance for the acrylated EVA terpolymer versus a conventional coalesced vinyl acrylic - a high-scrub product produced in North America similar to what most paint producers currently use in their solvent-containing waterbased paints. In all three of the PVCs, we added 6 percent coalescent (on binder solids) to the conventional vinyl acrylic and both binders were compared using Nacan's solvent-free formulations.

There is no loss in scrubs over the entire range of PVCs with Vinamul 3692. The EVA terpolymer gave improved performance over the conventional coalesced vinyl acrylic at low PVCs and equivalent performance in the high PVC flat. The panels dried for seven days as outlined in ASTM D2486.

When the seven-day period is viewed in the context of European testing, the indicated differential increases. (Because the scrub resistance of solvent-free paint systems increases over a period of several weeks, the DIN 53.778 standard scrub test in Germany requires panels to be dried for 28 days to allow for complete curing.)

We have noted in our lab tests that the temperature at which the panels are dried also has an impact on the scrubability: a panel which has been dried for several days at 5°C, and then placed at room temperature for two days, greatly increases in scrub performance.

Figure 3 shows the scrubability evaluation of the EVA terpolymer versus conventional commercially available binders for solvent-free paint, i.e. acrylic, styrene acrylic or vinyl acrylic in semi-gloss and eggshell formulations.

In the semi-gloss tests, the EVA terpolymer was evaluated in the Nacan formula, while the conventional solvent-free acrylic was evaluated in the recommended, supplier's suggested formula as it could not be made to work in our formula. Both binders were evaluated in

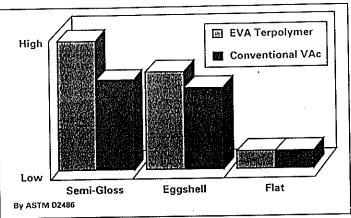


FIGURE 2. Scrub resistance: EVA terpolymer vs. conventional coalesced vinyl acrylic.

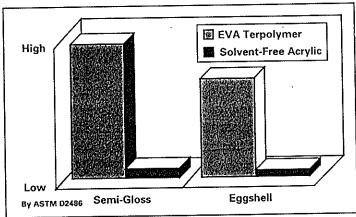


FIGURE 3. Scrub resistance: EVA terpolymer vs. conventional solvent-free acrylic.

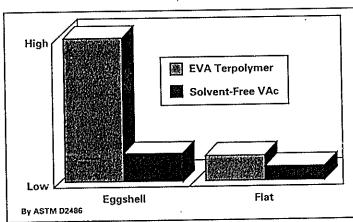


FIGURE 4. Scrub resistance: EVA terpolymer vs. conventional, solvent-free vinyl acrylic.

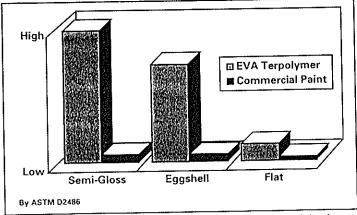


FIGURE 5. Scrub resistance: EVA terpolymer vs. commercial solvent-free paint.

the Nacan solvent-free eggshell formulation.

The acrylated EVA out-performed the conventional solvent-free acrylic by a wide margin in both the semigloss and eggshell formulations. In the actual scrub tests, dramatic results showed the acrylated EVA appearing almost unscrubbed in both forms.

When the acrylated EVA was compared to a conventional solvent-free vinyl acrylic (Figure 4), there was a similar large discrepancy in scrub resistance in the eggshell samples while in the flats the scrubs were closer, but the EVA terpolymer clearly showed improvement in performance.

Figure 5 evaluates the EVA terpolymer versus solvent-free paints commercially available in North America. Here again, results showed a wide margin of superiority across all three PVCs.

The two semi-gloss paints also demonstrated a marked difference in gloss stability, as shown in Figure 6. Over a three-month period, the gloss on the paint containing the EVA terpolymer remained reasonably stable, losing only three units, while the commercial solvent-free paint lost 20 units in the same period.

Future Developments

Great strides have been made in the technology available to substantially reduce VOC levels in water-based paints without losing performance and actually increasing scrub durability. But this technology is in its early stages and will continue to evolve as time and government regulations push the requirements.

There is still a lot of work to be done to further reduce the VOC levels in our paints. We will, in the near future,

have to work on tinting systems, rheology modifiers, binders, amines and analytical methods.

There are not many colorants that do not contain solvents, so solvent-free paints are not available in many colors. We look for as wide a range as there is currently for solvent-containing paints.

Additional work in rheology modification needs to be done to remove the solvents from a wider range of associative thick-

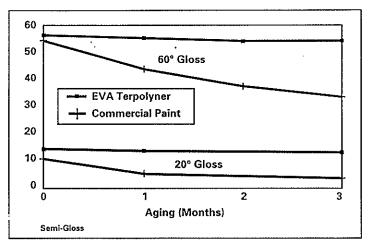


FIGURE 6. Gloss stability: EVA terpolymer vs. commercial solvent-free paint.

eners. Residual monomers and volatiles from the manufacture of thickeners also need to be reduced.

Binder manufacturers need to review raw materials and process controls to decrease the level of residual monomers and prevent the formation of volatile by-products and volatile impurities, or remove them from the finished emulsion.

In the case of surfactants, we must make sure they are water-based or are 100 percent active and contain no

VOCs. In our manufacturing processes, we must use optimum control to ensure efficient incorporation of free monomer, minimizing residual monomer left in the emulsion.

New non-volatile amines must be evaluated for pH adjustment. While inorganic alkali does the job, there are some risks involved.

Additional work in rheology modification needs to be done to remove the solvents from a wider range of associative thickeners.

All analytical methods for testing water-based paints should be reviewed and new standard tests for solvent-free paints established if the results warrant. This is a new and different technology and we have to think about how we are to measure the VOC level of a paint in the future. As the legislated levels come down, the test method must be more accurate and more reproducible than the EPA Test No. 24, which can even give negative results.

A new test has been developed in California which is reported to give more consistent results.

We are looking at a new and evolving technology. As we work to answer the questions it raises, we shall surely meet new challenges and discover new opportunities.

This article is based on a technical paper presented by Mr. Currie to the Canadian Society for Chemistry, Protective Coatings Division, at a Paint Technology Symposium held April 28 and 29, 1993, in Toronto and Montreal. Copies of the scrubability tests referred to may be obtained by contacting Mr. Currie.

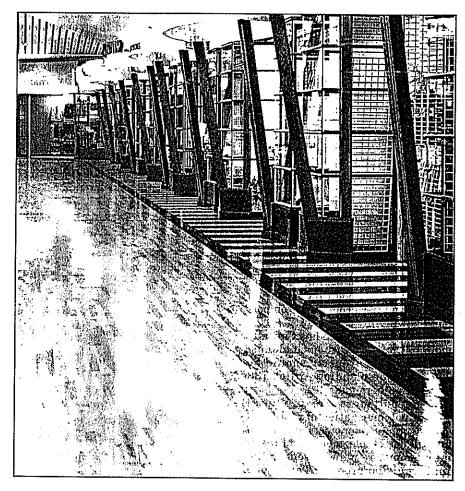
Water-Borne Technologies For Wood Floor Finishes

he rigorous and constant abuse sustained by bowling alley lanes is probably the toughest test to which a hardwood floor can be subjected. Day after day, bowling balls literally batter away at the very fibers of the wood lanes. Bowling has presented a unique challenge to coatings manufacturers over the years. But for one manufacturer, Atlas Products Inc., Des Moines, Iowa, meeting this challenge decades ago opened up opportunities in a variety of markets.

What began as a solution to the problem of providing protection for bowling lanes has become the answer for other wood floor applications. Atlas floor finishing products are now used on racquetball and basketball courts, in living rooms, dining rooms, kitchens, restaurants, shopping centers, dance halls and even roller rinks across the United States and in other countries around the world.

Historically, bowling alley operators have relied on lacquers, and later, moisture-cure urethanes (MCUs). While these coatings provide the necessary performance characteristics, they also have disadvantages. For starters, the toxic fumes these products release during application and drying present a health hazard for workers as well as a liability issue. The potential for flammability is also ever-present and has resulted, in some instances, in exorbitant insurance rates for bowling center operators who still use these products. Solvent-borne coatings have also been pegged as hazardous for the environment, and their use has been restricted and even banned in many areas of the country.

The first low-VOC coatings produced for the bowling market were not well received. Operators and professional applicators, used to tradi-



tional methods, were not comfortable with the performance of these new products and returned to the MCUs, despite their downside.

Expanding Into New Markets

Astuteness, insight and tenacity on the part of Atlas Products led to its successful development of viable alternative coatings and ultimate leadership in the business of low-VOC coatings for bowling alleys through its Perry-Austen International Inc. division in the 1970s. Its

Shopping center floors are among the demanding applications for water-borne floor finishing products.

success eventually encouraged Atlas to expand its technology into other wood floor markets and to continue development in addition to expanding market penetration through another Atlas division — Basic Coatings.

"We saw the challenge of wood floor finishing as an opportunity," says Lyle Middleton, chairman of The Atlas Companies. "In the early 70s, we began working more closely with our chief resins supplier, Zeneca Resins, Wilmington, Mass., to develop marketable, high-performance alternatives." This joint effort between Atlas and Zeneca served to benefit both companies. Zeneca, formerly ICI Resins US, had developed its NeoRez urethanes, the first water-borne urethanes which, in turn, enabled Perry-Austen to penetrate the bowling market with its line of Hydrolane finishes.

Twenty years later, Perry-Austen is still the market share leader in bowling lane finishes, and Basic Coatings has subsequently expanded into other applications. The company's first steps off the bowling lanes were onto interior sports floors with a product called Hydroline. The special features of this type of technology allowed school officials and operators of other athletic facilities to coat their floors in just a couple of days, without liability concerns.

New Markets, New Products

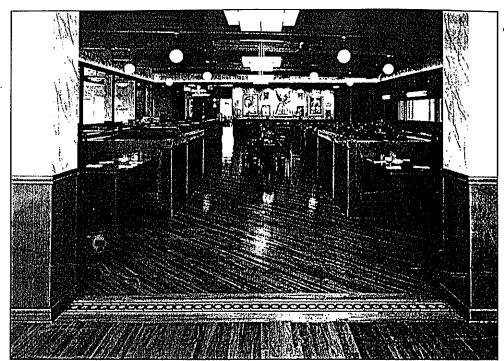
Hydroline also became widely used as a residential wood floor finish because many contractors were looking for a low-VOC, low-odor alternative to the oil-modified urethanes (OMUs) that dominated the market. These same contractors, however, wanted a waterbased urethane coating that could be applied in the same way as the OMUs. This presented Basic with a new challenge.

As a result, the company added two new products to its residential finish line. The first was Easy Street, a second generation product that utilizes Zeneca's water-borne urethane technology. Contractors can apply this product using

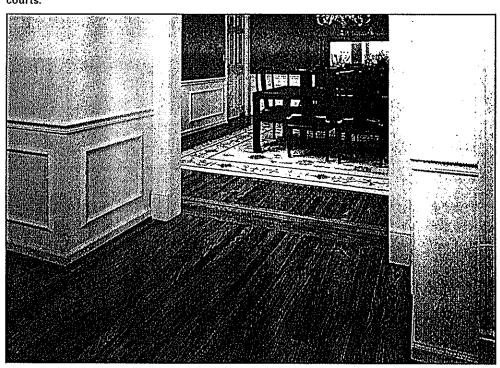
the method with which they are most comfortable.

More recently, Basic introduced Professional Image, a water-borne urethane/acrylic formulation that does not require a crosslinker.

Even with sports floor and residential markets showing consistent growth for Basic Coatings, Middleton says the company saw an opportunity in yet another market — commercial wood floors. Wood floors are becoming more popular in commercial locations, but because of their size and the extreme wear factor,



Floor finishing products from Atlas Products Inc., Des Moines, Iowa, are used in a variety of enduse applications, including restaurants (above), residential floors (below) and even basketball courts.



commercial floors can be difficult to finish and maintain. Basic developed Street Shoe, which has since become an industry standard for commercial wood floor finishes.

A True Partnership

Along the way, Middleton points out, Atlas worked closely with Zeneca Resins. "This has been the truest form of partnering," he says. "Through Zeneca's leadership in polymer technology, we were able to forge a meaningful working relationship."

Middleton adds that these efforts "have paid excellent dividends" for both companies. "The work has enhanced both organizations."

Middleton notes that wood floor coating technology has undergone significant changes in a short period of time. "We expect the future to present us with even more interesting challenges," he says. "With suppliers like Zeneca, we are able to work together in developing new products that meet the demands of the marketplace and contribute to the continued success of both companies."

Formulating Low-Odor, Low-VOC Interior Paints

By Robert J. Klein Section Manager, Coatings Air Products and Chemicals Inc., Allentown, Pa.

The entire coatings industry is undergoing a rapid shift in technology in an effort to reduce levels of organic volatiles. While the solvent-based systems are experiencing the most significant changes toward either water-based, high-solids or powder coatings, latexbased coatings are also being scrutinized as sources of VOCs and indoor

pollutants.

One advantage of latex paints over solvent paints for interior use is the lower odor of latex paints. This advantage is being exploited even further by low-odor, low-VOC paints that can be used in hotels, hospitals, schools and other areas where the facility cannot be shut down during painting to allow solvent odors to disperse. Such paints also reduce the concern over Sick Building Syndrome where off-gassing of building materials such as carpets, panelboard and paint is sometimes suspected of producing lingering indoor pollution problems.

Interior latex paints are usually not considered in the same category

solvent-based paints since they can be cleaned up with water, are nonflammable and usually produce less odor than solvent-based products. However, these products typically contain significant amounts of organics volatile which are added to several improve important properties of the paints. Eliminating these materials without completely reformulating the paint would seriously impair the properties of the paint or make it completely unusable.

The total elimination of organic volatiles from latex paints is not currently feasible if zero VOC is intended to mean below detectable limits. However, organic volatiles can be reduced to very low levels where odors and concern over indoor pollution are minimized. The EPA Reference Test Method 24 and ASTM D3960 Standard Practice for determining VOC levels in paints and related coatings are useful for solvent-based coatings but are not wellsuited for testing low-VOC, waterbased paints.

Latex paints are composed of binders, pigments and additives which are either dispersed in or dissolved in water. The organic volatiles in paint mainly come from additives that perform one or more of the following functions: binder coalescing aid, polymer plasticizer, freeze/thaw stabilizer, defoamer and carriers for other additives such as colorants,

thickening agents, surfactants and biocides. Reducing the volatile organics in paint to the lowest feasible levels requires careful selection of raw materials and the elimination of several raw materials altogether. Table I lists formulations for interior flat latex paints showing where VOCs are added to conventional latex paint formulations.

Binders for Low-VOC Paints

The most important raw material to be considered when formulating paint for low VOCs is the binder. A wide variety of emulsion polymers are used in interior paints. However, vinyl acrylic latices are the workhorse binders for this application because of their versatility and cost-effectiveness. This family of latex products provides good rheology, gloss and scrub resistance properties at low cost, which make them suitable for paint applications. These latices are copolymers primarily of vinyl acetate and butyl acrylate and are used in flat, eggshell and semi-

gloss paints. The ratio of butyl acrylate vinyl acetate mainly determines the minimum film forming temperature (MFFT), glass transition temperature (Tg) and relative hardness of the polymer. Increasing levels of butyl acrylate plasticizes or softens polymer as shown in Figure 1. However, paint formulations based on conventional vinyl

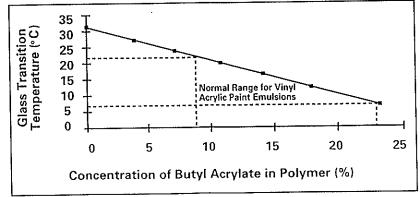


Figure 1 (above) shows the calculated glass transition temperature of vinyl acrylic latices as a function of butyl acrylate content.

TABLE I.	58 PV0	Interior	Latex Flat	Paint For	mulatione

Ingredient	Conventional Late Paint (#/100 Gal.)	ex Low VOC Paint (#/100 Gal.)	Category	VOC Content	
Water	300	300	_	_	
Natrosol Plus, Grade 330	0(1) 7	7	Additive	none	
Surfynol Tg Surfactant(2) 2	2	Additive	none	
Colloid 226 Dispersant(3)) 7	7	Additive	none	
Colloid 640 Defoamer(4)	2	2	Additive	partial	
Ti-Pure R-901(5)	125	125	Pigment	none	
Satintone W(6)	150	150	Pigment	none	
Duramite(7)	200	200	Pigment	none	
Kathon LX Biocide(8)	1	1	Additive	none	
Colloid 643 Defoamer(9)	3	3	Additive	partial	
Water	137	107		•	
Potassium Carbonate	3	0	Additive	none	
Propylene Glycol	20	0	Additive	all	
Texanol - Coalescent(10)	11	0	Additive	all	
High Scrub Vinyl-Acrylic (55% solids)	250	0	Binder	trace	
Airflex 738 Emulsion(11) (52% solids)	0	250	Binder	trace	
Yield, gallons	100.8	100.8			
Solids, %	51.7	51.1			
PVC, %	58	60		•	
Viscosity, KU	102	102			
Reflectance	91.83	91.78			
Contrast Ratio	0.971	0.974			
85°Sheen	1.7	1.5			
Open Time,	8 minutes	9-10 minutes			
(3 mil on Sheet Rock)					
Touchup at 50°F	Fair	Very Good		v	
Gardner Scrub	1700 cycles	1700 cycles			
(with 50% Ajax Slurry)	30% black show through	no black show through			

Product Key:

- (1) Aqualon
- (2) Air Products and Chemicals Inc.
- (3) Rhône Poulenc
- (4) Rhône Poulenc
- (5) E. I. DuPont deNemours and Co.
- (6) Engelhard Minerals and Chemicals
- (7) EEC America Inc.
- (8) Rohm and Haas
- (9) Colloids Inc.
- (10) Eastman Chemical
- (11) Air Products and Chemicals Inc.

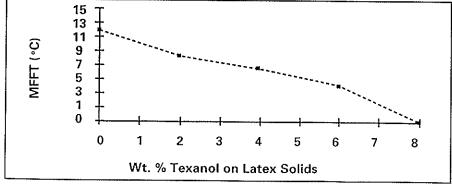


Figure 2 (above) shows the MFFT of a vinyl acrylic latex versus a weight percentage of Texanol.

acrylics require the addition of coalescing agents in order to achieve optimum performance properties. The properties most improved through the use of a coalescing agent are low-temperature film formation, touchup and scrub resistance. The effect of a coalescing agent on polymer properties is demonstrated in Figure 2 which shows the relationship between MFFT and concentration of coalescent for a vinvl acrylic latex.

Coalescing agents are a major source of VOCs in latex paints and are among the first additives to be eliminated in order to formulate a low-VOC. low-odor paint. In order to obtain optimum performance in such coatings, binders other than the standard vinyl acrylics will be required. Preferably, the binder will have an MFFT or Tg of less than about 5°C in order to give good lowtemperature coalescence and touchup properties.

Many latex binders are available that have low MFFTs and Tgs. However, several other criteria must be satisfied in

order to provide a replacement for the combination of vinyl acrylics plus coalescing agent. Pigment acceptance, scrub resistance and reasonable cost are important properties the emulsion must also possess.

Airflex 738 emulsion was developed to provide or exceed performance levels of conventionally formulated vinyl acrylics, without requiring the use of coalescing solvents. Airflex 738 latex is a terpolymer of vinyl acetate, vinyl chloride and ethylene.

Ethylene is a very efficient plasticizing comonomer for both vinyl acetate and vinyl chloride-based polymers. This represents a key element of Airflex 738 emulsion by providing the low-temperature film forming and touchup properties. As an additional benefit, ethylene imparts hydrolytic stability to vinyl acetate polymers so that vinyl acetate-ethylene copolymers and terpolymers have excellent resistance to alkaline conditions. Unlike vinyl acrylic latices that are attacked by alkaline conditions, Airflex 738 latex can be used in coatings over exterior masonry surfaces.

The vinyl chloride in Airflex 738 polymer emulsion provides exceptional toughness and abrasion resistance to this polymer so that even without the use of coalescing aids, paints based on Airflex 738 latex provide scrub resistance equal to or better than vinyl acrylic paints formulated at equal PVCs using coalescing

colvents.

Other key features of Airflex 738 emulsion include its fine particle size, which contributes to good low-temperature film formation, and the excellent pigment binding properties of the polymer. These features of Airflex 738 latex contribute to excellent performance in high-PVC paints relative to most other polymer systems.

In semi-gloss paint formulations, the relative softness of Airflex 738 latex produces coatings that are somewhat soft and which can experience blocking problems. In such formulations, it has been found that blending with a harder emulsion can provide both acceptable blocking resistance with good film formation and touchup performance at temperatures down to about 50°F. Freeze/thaw resistance has typically been maintained with such blends. However, this property should be checked when blending Airflex 738 latex with other emulsions.

Latex polymers are produced though polymerization of relatively volatile organic monomers and small, but still detectable, amounts of residual monomer remain present in the final emulsion product. This is one reason that a goal of truly zero VOC paints is an unrealistic target. Special care is taken during manufacture of Airflex 738 emulsion to minimize the residual monomer levels in order to allow paints to be formulated at the lowest levels of volatile organics and odor.

Glycols

As shown in Table I, glycols, which are added mainly to provide freeze/thaw stability, can be the primary contributor to VOCs in a latex paint formulation. Glycols are also helpful in imparting a longer open

time or lapping time for the paint during application and can improve leveling.

In-store tinting systems also use glycols to disperse colorants, and such tinting systems are not currently available at low-VOC levels. This sharply limits the choices of colors available in low-VOC paints. Low-VOC colorants are becoming available and a range of factory colors would be possible.

An important feature of Airflex 738 emulsion is that it can be formulated into paints that have freeze/thaw stability without the use of glycols. Paints formulated at pH values of greater than around 8.5 are typically stable to five freeze/thaw cycles. While this has held true for several paint formulations prepared in Air Products' labs, each new formulation should be checked for freeze/thaw stability, as other formulating variables may impact this property.

Formulating paints made with Airflex 738 latex to pHs over 8.5 requires the use of a base or buffer. Fugitive bases provide the best water resistance. However, bases such as ammonia or amines will contribute to the total organic volatiles of the paint. For the lowest VOC and odor levels, permanent bases such as potassium carbonate should be used.

Other Ingredients

Several other ingredients can contribute minor amounts of VOCs to the final paint formulation. For example, defoamers often contain mineral oils and mineral spirits; surfactants and biocides often contain alcohols or coalescing solvents; and some rheology modifiers, particularly the urethane associative thickeners, often contain solvents. In many cases, the benefits of these additives outweigh the minor increase in VOC content or odor. However, careful selection of these additives will reduce the total VOC content of the finished paint.

Conclusions

Although latex paints for interior service are not currently facing tighter controls on VOCs, there are areas where reductions in odors and organic volatiles are desirable. The primary sources of VOCs in paints are glycols and coalescing solvents. These ingredients can be eliminated without sacrificing freeze/thaw resistance, low-temperature performance, scrub resistance and other important properties if paints are formulated around a suitable latex binder or binder system. Additional reductions in VOCs can be made through careful selection of other additives.

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Water-borne urethane/ acrylic latex blends



By Dr. Richard G. Coogan, James J. Bilancieri and Gail Pollano

Dr. Richard G.: Coogan is urethane research manager. James J. Bilancieri is architectural coatings applications manager and Gail Pollano is industrial coatings applications manager, Zeneca Resins, 703 Main St., Wilmington, Mass. 01887. Phone: (508) 658-6600.

Introduction

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WATER-BORNE URETHANE dispersions, currently experiencing a 10-percent annual growth rate, are finding favor in many markets for a number of reasons. A principal reason for this growth is their low odor and easy clean-up.

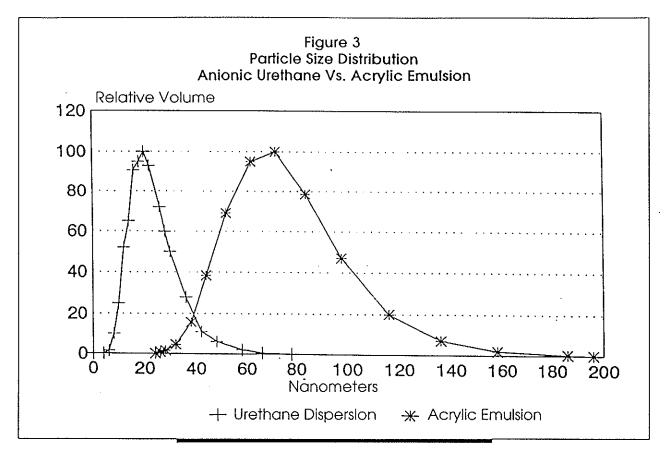
Another key reason is the fact that urethanes have been found to offer a key advantage in their ability to improve the film formation of acrylic latexes. Blending water-borne urethanes with acrylics can lead to lower VOCs in the formulated coatings while offering higher tensile strength and improved toughness.

The combined water-borne polymers are being utilized increasingly for coating plastic substrates because of the combined advantage of superior adhesion and impact resistance, an advantage not possible with either polymer on its own. The same is true in wood coatings applications.

Chemistry

Water-borne urethanes have been commercially available for about 20 years. The first commercial polymers were produced by emulsifying low-molecular-weight ure-

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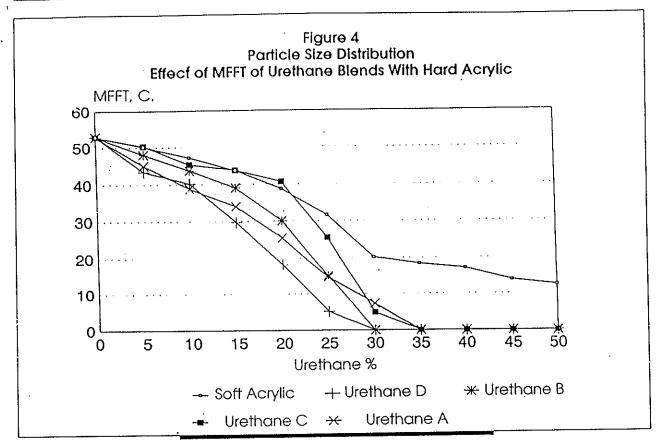
often use urethane and acrylic physical blends. Wood varnishes for floors, cabinetry and woodwork enhance the wood's natural beauty and protect against chemical and physical damage. A key to the performance of these finishes is the balance of urethane and acrylic latex concentration.

Urethanes impart impact resistance and toughness to the finish while acrylics promote adhesion, gloss and contribute strongly to proper rheology. The formulator can meet the durability requirements of a floor varnish or the flow, leveling and build needed for brushing varnishes by varying the concentration of the two polymer components.

One overlooked benefit of blending urethanes with acrylics is the synergistic effect of lower film formation temperature at reduced coalescing solvent levels, relative to the pure polymer coatings. The unique ability of urethane dispersions to promote film formation at lower VOC is due to a variety of reasons. Urethane dispersions are produced at a relatively small particle size compared to acrylic latexes (Figure 1). Upon drying, the larger surface area of the urethane dispersion generates tremendous hydrostatic force to drive the particles together. Also, the urethane particle morphology is like a sponge, with holes and pockets filled with water.

Water within the urethane particle, which evaporates as the coating dries, helps to swell and soften the polymer, allowing easier deformation and improved film formation. Acrylic latex particles are more dense in nature, like golf balls, and require softening by cosolvent to form a film.

Urethane polymers also contain two segments. The soft segment within the urethane polymer usually has a low Tg, in the range of minus 60 to minus 30 degrees C., which can assist greatly in film formation. These factors give urethanes the unique ability to coalesce at low cosolvent levels, but still



form hard films.

To demonstrate this phenomenon, consider the following example. Urethane A is an aliphatic urethane dispersion containing 400 grams of VOCs per liter. Urethane A can be blended with a hard coalesced acrylic latex (263 g/I VOC) at a ratio of 1:1, giving the blend a VOC of 335 g/1. The MFFT (minimum film formation temperature) will be 0 degrees C.

Effectively, this system is over-coalesced. An alternative to this mixture is to blend Urethane A with an uncoalesced version of the same acrylic. This new mixture would still have an MFFT of 0 degrees C., but is only 200 g/l VOC.

The depression of MFFT by blending urethanes in acrylics is further demonstrated in Figure 4. A hard acrylic polymer (MFFT = 53 degrees C.) is blended with a variety of urethanes (**Table 1**) at different blend ratios. The results of this study indicate that MFFTs of 0 degrees C. can be achieved at 30-35 percent blend levels of urethane dispersion to 65-70 percent acrylic.

Urethane D, for example, when blended at 30-percent levels with the hard acrylic, exhibits an MFFT of 0 degrees C. with a VOC of 100 g/1. Even lower levels of VOC can be achieved when more elastic urethanes such as Urethane C are used. A blend of Urethane C with the hard acrylic at 35/65 ratio will yield an MFFT of 0 degrees C. and a VOC level of 100 g/l.

It is interesting to note that in blends of the hard acrylic with 50 percent of the soft acrylic, the resulting MFFT never reaches 0 degrees C.

Conclusion

The majority of the urethane dispersions now used are formulated in blends with acrylic latexes. We would expect that the current growth rate of urethane dispersions will continue in the foreseeable future, due

*	Physical Pro	Table 1 operties of Ureth	anes	**************************************
	Urethane A R-9409	Urenthane B R-972	Urethane C R-967	Urethane D R-960
Type Konlg hardness, sec. VOC, g/l Cosolvent Tenslle, psl Elongatlon, %	Aromatic 115 378 NMP/MEK 6400 250	Aliphatic 35 245 NMP 7500	Aliphatic 12 25 None 3000 600	Allphatic 95 400 NMP 6500 200

to the understandable tendency of formulators to blend them with acrylic latexes in order to achieve the best balance of performance and price.

Technical Focus: Resins

Acrylic lacquer water-borne dispersions:

Very low VOCs, lacquer-type performance

By Rich Johnson

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Introduction

A S VOC REQUIREMENTS for coatings continue to be lowered, formulators must seek new technologies to meet environmental limitations. The answers from the early 1990s are no longer acceptable (420 grams per liter or 3.5 pounds per gal-

lon). Water-borne dispersions may be the solution, now and in the future. Coatings formulations based on water-borne dispersions can be made as low as 70 g/l VOC.

This is the first in a series of three articles describing the formulation and performance of acrylic lacquer, aliphatic-urethane acrylic lacquer, air-dry alkyd and baking saturated polyester dispersions, all of which have little or no compromise in performance compared to conventional systems. The other articles in this series will appear in future editions.

Performance will be compared to waterborne and conventional solvent-borne coatings. It will be shown that dispersions have very low VOCs and excellent dry times.

Water-borne thermoplastic acrylic air-dry dispersions

The coatings industry wants to comply with environmental demands, but how do

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Table 1 Thermoplastic Acrylic Dispersion

Theoretical solids (1	VVM) 33%
Volatiles	water/ammonia
	EGMBE <3%
Viscosity, Gardner	Holdt G-N
Weight per gallon	8.75
Acid value	55-65
Appearance	translucent/amber
Modification	None
Flash point	>200° F.

we achieve lower VOCs and minimize hazardous air pollutants (HAPs) without compromising performance?

Water-borne acrylic lacquer dispersions have VOC levels well below requirements and offer outstanding dry and performance characteristics. This article will show exactly how these dispersions compare to conventional and water-borne coatings.

The two water-borne acrylic dispersions to be examined are a thermoplastic acrylic dispersion and an aliphatic urethane-modified acrylic dispersion. Both systems offer

Table 3 Paint Properties, Aerosol Formulation

% Nonvolatile	wt.: 36.75	vol.: 25.38
Weight per gal	llon	9.82
Pigment/binde	er ratio	0.90
Pigment volum	ie concentro	ation 20.22
Theoretical		•
VOC	1.30 lb./gd	al. 156.18 g/L
Viscosity, No. 4	Ford cup (se	ec.) 23 ·
На		8.2

very low VOCs, stability (with minimal hydrolysis), excellent sprayability, fast dry and repairability using solvent-borne lacquers.

Unmodified acrylic lacquer

The first formulation examined is a thermoplastic acrylic resin that is predispersed in water, ammonia and less than 3 percent 2-butoxy ethanol. The specifications of the resin, as supplied, are shown in **Table 1**.

This acrylic is recommended for use in the following applications: aerosol lacquers,

Table 2 Aerosol Starting-Point Formulation

Ingredients	Pounds	Gallons
Water-borne acrylic dispersion 16-7251	261.1	29.93
Byk 181 (Byk-Chemie)	1.2	0.14
Raybo 62 (Raybo Chemical Co.)	1.2	0.14
Byk 020 (Byk-Chemie)	1.2	0.16
Plasticizer KP-140 (C.P. Hall Co.)	6.9	0.81
Ti-Pure R-702 titanium dioxide (Du Pont Co., Inc.)	170.9	5.13
Grind to 7 Hegman, then add, with agitation:		
Water-borne acrylic dispersion 016-7215	261.9	29.93
Premix, then add:		
Delonized water	230.5	27.68
Ektasolve EEH (Eastman Chemical Co.)	36.8	5.01
Plasticizer KP-140 (C.P. Hall Co.)	6.9	0.81
Byk-307 (Byk-Chemie)	1.2	0.13
Total	981.6	100.00

Note: Due to the mechanical stability of this resin, the formulation can be high-speed dispersed, sand milled or pebble milled.

Coating	Table Property Comp	e 5 5 Sarison, Aerosol Pain	t
	16-7251	Commercial water-bome aerosol	commercial solvent-bome aerosol
Aerosol VOC	25%	67%	85%
Dry time to set	45 mln.	90 mln.	30 mln.
DFT (mlls)	1.5	1.5	1.5
Gloss (60/20)	85/70	89/81	87/60
Pencil hardness	F	HB	F
Adhesion	100%	100%	100%
Impact(direct/reverse)	30/10	60/10	30/10
Humidity resistance (170 hou	urs)		
Gloss retention	95%	35%	95%
Adheslon	99%	99%	99%
Blistering	none	few #8	none
Stain resistance (24 hours)			
Water `	NE	NE NE	NE
5% acetic acld	S	. S	SI .
5% sulfuric acid	SI	SI	NE
Mustard (1 hour)	SI	SI	SI
NE — no eff	ect SI—slight	t mark S—stalned/	softened

Table 4	
Aerosol Formulation for	4-Ounce Jars
Paint (grams)	100
DME (grams)	24
Actuator: Newman-Gre	een Dynamist

clear wood coatings, plastic coatings, and some inks.

Yes, aerosol. We wanted to demonstrate that hydrolysis, pH drift and very limited shelf life are of little concern with acrylics. Given this stability, along with low VOCs and fast air dry, aerosol coatings are a natural.

A typical aerosol starting-point formulation is found in Table 2. Table 3 shows typical paint properties.

A typical aerosol formulation was prepared in glass jars for stability testing. This formulation is shown in Table 4.

The coating atomized well using the recommended actuator, and it yielded coatings with fast dry and excellent gloss. It should

Table 6 Resin Properties, Aliphatic Urethane-Modified Acrylic Dispersion

Resin	170-2291
Theoretical solids (NVM) 26%
Volatiles	ammonia/water
	EGMBE <2%
Viscosity, Gardner	Holdt H-N
Welght per gallon	8.65
Acid value	. 55 - 65
Appearance	translucent/amber
Modification	aliphatic urethane
Flash point	>200° F.

be noted, however, that the choice of actuator significantly affects the gloss.

Coating properties of the dispersion acrylic are compared to commercial water-reducible and commercial solvent-based aerosol coatings in Table 5.

Although the VOC is measured as a percent in the aerosol, the actual VOC is less than 160 g/l. The acrylic lacquer dispersion

Technical Focus:

Table 7 Clear Formulation fo	r Wood	
Ingredients	Pounds	Gallons
Water-borne acryllc dispersion 170-2291	713.0	82.43
Add, under agitation:		32.10
Byk 020 (Byk-Chemle) Plasticizer KP-140 (C.P. Hall Co.)	4.4 5.9	0.60 0.69
Raybo 62 Hydroflo (Raybo Chemical Co.) Byk-307 (Byk-Chemie)	4.4 4.4	0.53 0.51
Ektasolve EEH (Eastman Chemical Co.) Premix, then add:	4.4	0.60
Delonized water Michem Emulsion 34935 (Michelman, Inc.) Delonized water	22.9 22.9 76.0	2.75 2.76 9.13
Total .	858.3	100.0

	Table 8 Clear Formulation for Wood	[
% Nonvolatile Welght per gallon Theoretical VOC Viscosity, #4 Ford cup (sec.) pH	weight: 23.80 0.96 lb./gal.	volume: 22.02 8.58 115 g/I 26 8.50

,	170-2291	XAMA 2	Competitive Resin	Commercial Water-Borne Varnish
VOC (lb./gal.)	1.0 ·	0.9	1.8	2.3
DFT (mils)	1.3	1.4	1.6	1.5
Gloss (60/20)	99/82	101/68	102/83	107/81
Sward hardness	52	50	36	66
Adhesion	80%	. 80%	80%	90%
Cold check (5 cycles) Print resistance (6.3 lb.	pass	pass	pass	pass
@ 25° C. Staln resistance (24 hour	pass s)	pass	pass	pass
Water	NE	NE	NE .	SI
50% Ethanol	SII	NE	NE	SI
5% Acetic acid	S	SII	S	SI
Mustard (1 hour)	NE	NE	ŇE	NE Si

performs well on metal, plastic or wood. A point to note is that this acrylic water-borne coating can be repaired with a solvent-borne lacquer. The water-borne resin has hydroxyl functionality if crosslinking is desired.

Aliphatic urethane-modified thermoplastic acrylic

The second dispersion is an aliphatic urethane-modified thermoplastic acrylic. Evaluations of the pure acrylic lacquers indicated that for some end uses, particularly wood and plastic substrates, the flexibility required upgrading, while excellent stability clarity, and dry times were retained. A modification with an aliphatic urethane met these needs.

The resin specifications for this aliphatic urethane-modified acrylic dispersion are shown in **Table 6**.

This resin is recommended for wood, plas-

tic and glass coatings, fast-dry enamels and touch-up enamels. A typical clear formulation for wood substrates is found in **Table 7**. The paint properties are shown in **Table 8**.

Coating properties of the urethane-modified acrylic are compared to a commercial water-borne varnish, an oil-modified (TDI) urethane varnish, a competitive water-borne product, and a polymericaziridine cross-linked with the urethane-modified acrylic to further upgrade the toughness and performance (see second column in Table 9).

Conclusions

It has been shown that water-borne acrylic dispersions offer the following: fast dry, very low VOCs, hydrolytic stability, mechanical stability, and excellent film performance. This offers opportunities for breakthroughs to new low-VOC, air-dry coatings with effective performance.



Application Case History

Historic Lighthouse Showcases

HE FOCAL POINT OF Hunting Island State Park, a three-mile-long, one-mile-wide barrier reef off the South Carolina coast, is a century-old, 140-ft.-high lighthouse. The commanding structure was built to provide a beacon for ships plying the shallow coastal waters between Charleston and Savannah. No longer playing that traditional role, it now serves as a lure and guideline for the thousands of sightseers, campers and vacationers who visit the popular park each year.

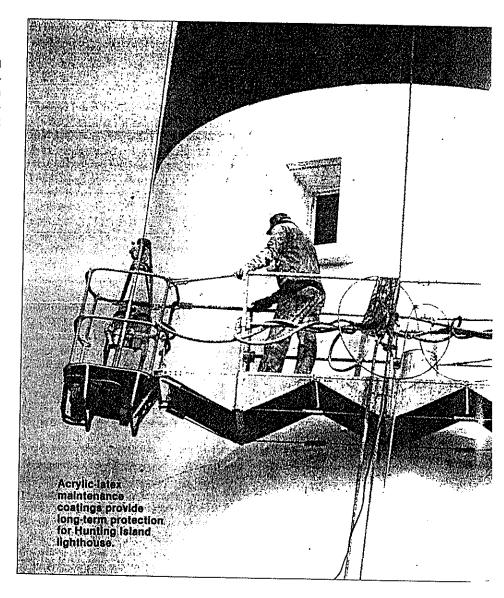
Currently, the lighthouse fills another function, providing an example of the long-term, trouble-free protection that modern acrylic-latex maintenance coatings provide under the most demanding conditions.

More than six years ago, as part of a major restoration program, a state-of-the-art acrylic-latex maintenance paint system was applied to the lighthouse's badly deteriorated cast-iron plate. Remarkably, in view of the severe conditions under which the maintenance paint must perform, the coating is still essentially "good as new."

"We have been tremendously pleased with the performance of this paint system," says Marshall West, superintendent of Hunting Island State Park. "Its durability is truly remarkable considering the state of the lighthouse prior to being refinished and the extreme environmental conditions to which any paint used here is exposed. We are also very impressed—even a little astonished—with the way a paint based on water has held up on a surface as subject to rust and corrosion as cast-iron, especially considering the short lifespan of earlier, oil-based coatings."

A Torture Chamber for Paint

The Hunting Island lighthouse is a perfect test ground for a maintenance coating. The climate on Hunting Island is characterized for much of the year by protracted and intense sunlight, high



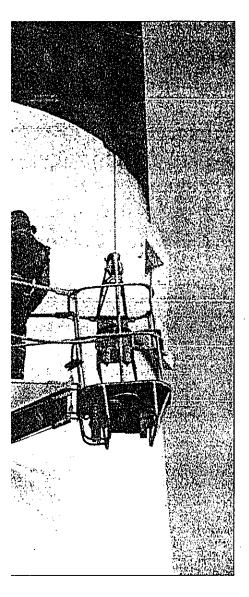
temperatures and high humidity. Added to this are frequent and heavy rains, fog and constant wind-driven salty spray. The net result is a real torture chamber for any protective coating.

Then there is the matter of the substrate that the paint must embellish and protect. The lighthouse, erected in 1875 at a cost of \$102,000, is composed of interlocking cast-iron plates weighing 1,200 pounds each. These plates are bolted together through overlapping

flanges to form a series of graduated rings. At its base, the structure is 27.7 feet in diameter; at the top, 13.1 feet. The exterior surface area totals 9,650 sq. ft.

Cast iron per se is highly susceptible to rust and corrosion. This problem was accentuated at the lighthouse because the plate used was not of a very high quality; harboring many impurities. As a result, over the years, a myriad of "worm holes" developed in the metal.

Water-Based Maintenance Paint



These ranged in diameter from pencilpoint size to over an inch in diameter. The cavities provided a collecting point for rust-stained water, which subsequently ran down the plates, causing unsightly streaking.

From Bad to Worse

An attempt to correct the damage in 1974 only aggravated the condition. The most severely deteriorated section of the lighthouse, a trapezoidal area on the

northeast (no sun) side of the structure 12 feet at the top, 20 feet wide at the bottom and 80 feet high was coated with a thermoplastic, solvent-based mastic compound in an effort to seal off the deepest pit holes in the iron plates. Then the entire lighthouse was finished with an oil-based paint.

This approach proved disastrous. The mastic application was relatively thin (about 5-10 mils dry) and the formulation employed was not UV-light stable. In addition, the oil-based topcoat degraded rather quickly; it cracked, chipped and faded and became covered with rust stains. This attempt resulted in the lighthouse, a one-time scenic highlight of the park, becoming a festering eyesore.

The South Carolina Department of Parks, Recreation and Tourism was fully aware of the problem and anxious to take remedial action. However, it was unable to do so because of budget curtailments.

In 1981, the Rohm and Haas Co., Philadelphia, began to take notice of the dilapidated lighthouse following a vacation visit to the park by Jack Weitz, a technical representative in the firm's Polymers, Monomers and Resins business group. Weitz, a "collector" of lighthouses, was impressed with the imposing structure, but distressed by its state of disrepair. But, true to his salesman's calling, he saw the problem as an opportunity and decided that the structure would make an ideal exposure site to test and substantiate the outstanding performance offered by water-based marine and maintenance coatings based on acrylic emulsion polymers manufactured by Rohm and Haas, Weitz presented his case to the appropriate marketing group who subsequently accepted his proposal.

A Unique Opportuniity

"The lighthouse presented us with a unique opportunity to test an acrylic-la-

tex maintenance coating system under the most severe conditions. We could not have asked for a better proving ground," says David Watson, market manager for marine and maintenance coatings at Rohm and Haas. "We were also intrigued by the prospect of using the latest acrylic coatings technology to restore and preserve a national landmark."

Park officials were prompt in accepting the Rohm and Haas proposal to employ the lighthouse as a test site, particularly since the refinishing job would be done under the supervision of Rohm and Haas technical personnel.

The coating system selected for this restoration and preservation task consisted of a red (iron oxide-pigmented), corrosion-resistant latex primer, white midcoat and a semi-gloss topcoat in white and black shades. The primer and midcoat were based on Rhoplex MV-23 acrylic emulsion; the topcoat on Rhoplex MV-9 acrylic emulsion. Both of these emulsions were commercial products that had been available for a number of years.

Many quality maintenance paints based on these emulsions were available on the market. However, Rohm and Haas chemists needed to know the exact composition of the products that would be used on the lighthouse in order to make correct performance evaluations. In addition, the paints were to be applied by airless sprayers, so they had to be fine-tuned for that method of application. Because of this, the formulations used on the Hunting Island lighthouse were developed in the Research Laboratories of Rohm and Haas; these were typical of the water-borne maintenance coatings available to the market. Commercial quantities of the paints were then prepared to specifications by Gilman Paint Co., Chattanooga, Tenn.

The components of the primer and midcoat, other than the pigments, are

Before Chipped, cracked and faded paint combined with rust streaks to change the cast-iron lighthouse into a festering eyesore.

essentially the same. The only difference between the two formulations is the inclusion of zinc chromate in the primer. In accord with standard practices of the time, the maintenance primer employed on the lighthouse contained zinc chromate for maximum resistance to flash rusting. (Even in 1982, chromate pigments were coming under fire from regulatory agencies for their toxicity. As a result, Rohm and Haas chemists had been investigating the possibility of developing chromate-free primers without any sacrifice in performance.)

Rhoplex MV-23 acrylic emulsion, the vehicle for the primer and midcoat, is a high-performance polymer designed specifically for the formulation of water-borne maintenance paints. The polymer imparts to a maintenance paint

excellent resistance to flash and early rusting and good long-term corrosion resistance. Maintenance paints based on Rhoplex MV-23 are also characterized by ease of application and cleanup, fast drying time, outstanding adhesion to a variety of substrates, and resistance to discoloration and other forms of degradation on prolonged exposure to the elements and sunlight. An additional application advantage is the absence of offensive odor or hazardous fumes.

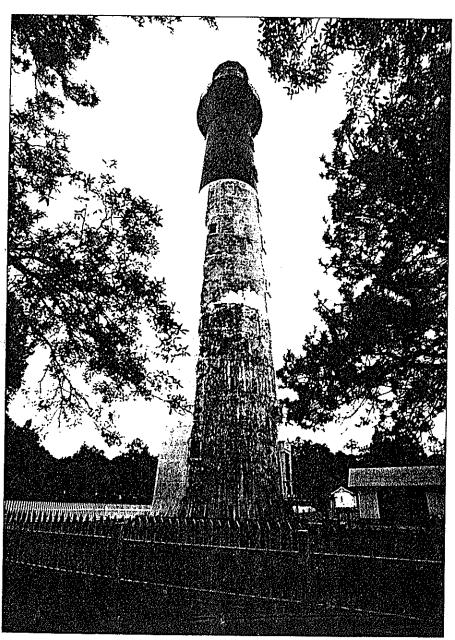
Other key components of the primer and midcoat formulations are: Methyl Carbitol, Dispersant QR-681M, Triton CF-10 surfactant, Drew L-405 defoamer, Halox BW-191 pigment, and Kadox French-process zinc oxide. Although each of these ingredients plays a different role, all were chosen because they contribute to the overall corrosion resistance of the formulation.

Kadox 515 zinc oxide is normally employed as a mildewstat in paints. However, in these maintenance coatings, it was added also because it synergizes with Rhoplex MV-23 in a unique way to maximize the corrosion resistance of the formulations. Dispersant QR-681M, which is also a product of Rohm and Haas Co., was designed to be compatible with both Rhoplex MV-23 emulsion and corrosion-resistant reactive pigments. It also helps promote corrosion resistance by helping the emulsion form a tighter, more continuous film. Optimum use levels range from 2.25 to 2.75 percent solids on pigment. Laboratory trials showed that Halox BW-191, a non-toxic pigment, would contribute an added measure of corrosion resistance: for this reason it was incorporated in the primer and midcoats.

Methyl Carbitol was employed in the primer and midcoat formulations instead of glycols to control open time and impart freeze-thaw resistance. Because it is more volatile than glycols, Methyl Carbitol leaves the paint film faster, enabling the film to develop greater early rust resistance and hardness. This lessened the time that the vulnerable iron substrate was exposed to ambient moisture. Drew L-405 and Drew L-493 defoamers were added to minimize pinholing and thereby help ensure good film integrity during airless spray application.

Topcoat Formulations

The acrylic vehicle for the topcoat, Rhoplex MV-9 emulsion, had long been utilized as the binder of choice for topcoat systems employing Rhoplex MV-23 primers. Topcoats based on Rhoplex MV-9 emulsion are hard and have ex-



cellent resistance to corrosion chemicals and solvents. At the same time, they provide the excellent durability, superb stability to ultraviolet radiation, rapid drying time, and easy water cleanup imparted by other Rhoplex maintenance emulsions.

In order to optimize the airless spray coverage properties of the Rhoplex MV-9 topcoats, a defoamer evaluation was done using the white topcoat formulation. The results showed that Colloid 643 gave the best balance of airless spray properties (resistance to macro/micro foam formation), while maintaining good gloss properties.

Rohm and Haas also formulated a special two-part acrylic-modified cementitious compound to be used as a hole-filler for the numerous pits in the cast-iron plates of the lighthouse. Component A of the compound consisted of Rhoplex MC-76 acrylic emulsion, Nopco NXZ, and water. Component B comprised Type I, gray Portland ce-

ment and Extendosphere CG glass beads. The glass beads were incorporated to prevent settling of the compound while maintaining good corrosion resistance.

As an essentia. "irst step, the metal plate was sandblasted to provide a sound, clean substrate. "Removing the gummy mastic compound from the northeast side of the structure was the worst part of the job," says Espie (Butch) Joyce, Utility Service, Madison, N.C., the firm that handled the refinishing assignment. "That just about broke our back. We used more than 15 tons of sand for the section; the rest of the lighthouse only took an additional three and a half tons."

Following the surface preparation, one coat of the Rhoplex MV-23-based red primer was applied by airless spray (Grayco Bulldog air-driven sprayer; No. 19 tip) to the lighthouse at a film thickness of 2 to 3 mils dry. Each coat was applied at a dry film thickness of 2 to 2.5 mils. Thousands of holes in the castiron plates were filled with the cement-modified, corrosion-resistant acrylic compound. In March of 1983, black and white acrylic gloss paints based on Rhoplex MV-99 were applied by airless spray to lighthouse body. The dry film thickness obtained was 1.5 to 2.5 mils.

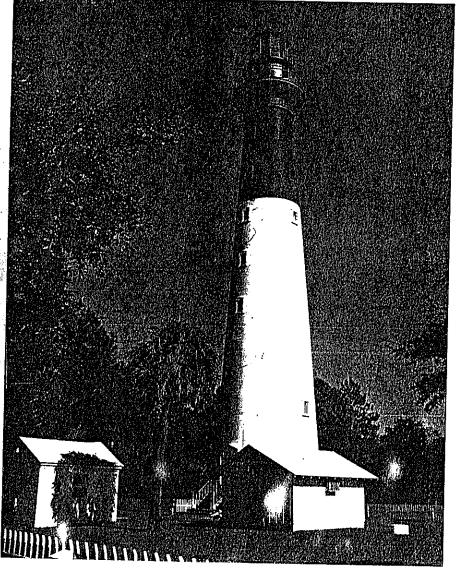
Facelifting Results

"The acrylic coatings went on like cream," says Butch Joyce. "They applied as well as any paint we ever used, and the soap-and-water cleanup offered by a water-based system was great compared to work involved with alkyd paints. In addition, our crew appreciated the absence of any irritating solvent fumes."

The system has now been in place more than six years and has held up extremely well. Perhaps 14 minuscule rust spots can be found on the structure, but considering the multitude and magnitude of the holes in the cast iron plates, this is remarkable."I don't see how any coating could provide better performance in terms of long-term durability and ease of care," reports Park Superintendent Marshall West. "The system has exceeded our expectations in every respect. It has required essentially zero maintenance and still looks like it was applied yesterday. About all we've had to do spot-paint small sections at the top ar _ bottom where the coating had been defaced by vandalism."

"I doubt if the lighthouse has ever looked so good for so long a stretch," West adds.

After
The acrylic coatings
have been in place
more than six years
and have held up well
in the harsh
environment.



Environmental Exposure Testing of Low VOC Coatings for Steel Bridges

by John Peart, Federal Highway Administration, and Robert A. Kogler, Jr., Ocean City Research Corporation

Editor's Note: An earlier version of this article was presented at SSPC 93, held in New Orleans, LA on November 13-18, 1993, and it was published in the SSPC 93 Proceedings, SSPC Report No. 93.06.

Exposure rack at the natural marine exposure site in Sea Isle, NJ

Courtesy of Ocean City Research Corp.

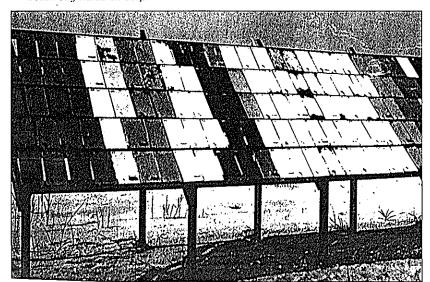
total of 47 corrosion control coatings of various generic types were applied to steel test panels and exposed to the natural marine environment. Test panels were prepared according to SSPC-SP 10 (Near White Blast), SSPC-SP 2 (Pre-Rusted and Hand Tool-Cleaned), and SSPC-SP 3 (Pre-Rusted and Power Tool-Cleaned) surface preparations. These coating systems have been periodically evaluated for rusting and cutback at intentional scribes throughout a three- to four-year exposure period. Of the coating systems tested, 38 have a volatile organic compound (VOC) content of 340 g/L (2.8 lbs/gal.) or less. The remaining 9 coating systems have higher VOC levels and were employed as controls. After 3 to 4 years of natu-

ral exposure in a marine environment, the corrosion control performance of several of the low VOC test systems of various generic types meets or exceeds that of the best performing control (high VOC) systems.

The best performing, conventionally applied, low VOC coating systems all employed zinc-rich (organic and inorganic) primers. Among the best performing barrier (nonzinc) coating systems were a three-coat water-borne acrylic coating, an epoxy mastic/urethane, an epoxy mastic/water-borne epoxy enamel, and a three-coat water-borne styrene acrylic.

To address the potential technical consequences of the pending national rule limiting the VOC content of architectural and industrial maintenance (AIM) coatings, the Federal Highway Administration (FHWA) developed and sponsored a comprehensive test program to determine the corrosion control performance of the various low VOC coatings on the market. This ongoing program began in 1988. In anticipation of the architectural rule for VOCs, a maximum VOC limit of 340 g/L (2.8 lbs/gal.) was set for all test coatings. This limit was chosen based on the best estimate of the pending regulation at the time the test coatings were selected (1988/1989). In addition, to accommodate further reductions, several systems chosen for the test are well below the 340 g/L (2.8 lbs/gal.) limit.

In meeting the program goals, FHWA intended to provide the state and local bridge authorities with straightforward, reasonable data for specifying VOC-compliant coatings for bridge painting. In addition, since the testing involves the parallel natural exposure



		·	es.
·	•		

of a large number of coating systems over a number of different typical surface preparations, the data will be useful in comparing the relative performance of specific coating systems over various surface preparations.

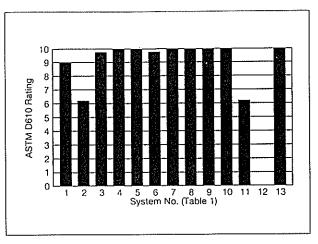
The following program objectives specifically describe the intent of the program. The first objective briefly outlines the various parameters of the testing. The second objective addresses the intent of FHWA to use the data generated to develop a life-cycle cost guide (based on coating system cost vs. tested performance) for state and local bridge authorities.

- Identify cost-effective, environmentally acceptable materials and methods for the corrosion protection of steel bridge components. These materials and processes shall comply with VOC, hazardous material, and hazardous waste control requirements. Suitable corrosion protection materials and processes shall be identified for shop-fabricated structures, site painting of new structures, and maintenance painting of old structures.
- Provide a projected life-cycle cost comparison for the identified corrosion control options for each bridge component and/or area.

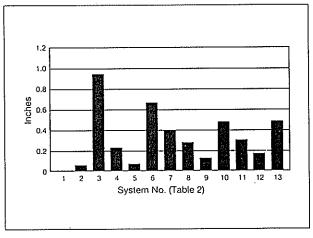
Technical Approach

The test program spans 7 years. For management, the program is divided into 5 distinct tasks, outlined below. The accelerated laboratory test data were recently published by FHWA under separate cover. The present article gives results of natural marine exposure testing from Tasks C and D.

- Task A, Regulation and materials review: Federal, state, and local environmental regulators were contacted to determine current and pending VOC regulations affecting coating operations. Coatings vendors were surveyed to determine the state-of-the-art in commercially available bridge coating materials.
- Task B, Bridge component and state department of transportation (DOT) surveys: State
 DOT bridge personnel were interviewed to determine present painting practices and the
 impact of environmental regulations
 throughout the country.



■ Fig. 1
Rust ratings of systems at Sea Isle test site after 4 years' natural marine exposure (SP 10 surface preparation)



■ Fig. 2 Scribe cutback (inches) of conventional low VOC systems at Sea Isle test site after 4 years' natural marine exposure (SP 10 surface preparation); 1 inch = 25.4 millimeters

- Task C, Accelerated laboratory screening tests: Cyclic salt fog and brine solution immersion testing was conducted on 34 coating systems.² Along with laboratory adhesion, water penetration, and parallel natural marine exposure testing, these tests were used to screen systems for Task D long-term exposure. The natural marine exposure panels remain exposed to provide long-term performance data on the 34 original test systems.
- Task D, Field testing: Thirteen coating systems are presently exposed to the natural environment in 3 separate locations: Ocean City Research Corporation Natural Marine Exposure Test Site (OCRC). Sea Isle, NJ; Doullut Canal Bridge, Empire, LA; and Mathis Bridge, Toms River, NJ. The exposure site panels are

Table 1 Task C Test Systems

System#	Generic Description	Dry Film Thickness (mils)	VOC Content (gram/liter)
1	Water-borne inorganic zinc	3.2	0
2	Water-borne inorganic zinc/acrylic	5/2	0/160
3	Epoxy/aliphatic urethane	4/6	175/263
4	Epoxy mastic/aliphatic urethane	8/2	84/300
5	Organic zinc/epoxy/aliphatic urethane	4/4/5	292/323/267
6	Aluminum epoxy/acrylic latex	6/3	250/250
7	Aluminum epoxy/acrylic latex	5/4	86/200
8	Styrene acrylic/styrene acrylic/100 percent acrylic finish/100 percent acrylic finish	4/6/9/9	30/30/140/140
9	Ethyl silicate inorganic zinc/epoxy/aliphatic urethane	3/4/2	264/320/300
10	Acrylic latex (three-coat)	3/3/3	150/150/150
11	Water-borne vinyl/water-borne vinyl	3/3	205/205
12	Acrylic latex/acrylic latex	3.5/2.5	150/150
13	High solids phenolic/high solids phenolic/ 100 percent acrylic finish/100 percent acrylic finish	3/6/11/11	282/282/140/14
14	BLSC oil-alkyd/BLSC oil-alkyd/BLSC oil-alkyd	2.0/1.5/1.5	*
15	Red lead-linseed oil/red lead-linseed oil/BLSC oil-alkyd	2.0/1.5/1.0	*
16	Inorganic zinc solvent-borne/vinyl wash primer/high build vinyl	3.0/0.5/5.0	4:
17	Ethyl silicate inorganic zinc/polyamide epoxy/aliphatic urethane	3.0/4.0/2.0	*
18	Zinc-rich epoxy/zinc-rich epoxy/wash primer/vinyl aluminum	3.0/2.0/2.0	#
19	Zinc-rich urethane/polyamide epoxy/aliphatic urethane	4.0/3.5/1.0	*
20	Polyamide epoxy MIL-P-24441 (three-coat)	3.0/3.0/3.0	*
21	Wire-sprayed zinc	5.6	0
22	Wire-sprayed zinc/vinyl seal coat	5/2	0/205
23	Wire-sprayed 85-15	6	0
24	Wire-sprayed 85-15/vinyl seal coat	6/3	. 0/205
25	Wire-sprayed aluminum	5	0
26	Wire-sprayed aluminum/vinyl seal coat	6/2	0/205
:7	Powder-sprayed zinc	9.5	0
18	Powder-sprayed aluminum	9.7	0
:9	Powder-sprayed zinc/vinyl seal coat	8/5	0/205
()	Flaine-sprayed epoxy powder	10	0
1	TGIC-cured polyester	6	0
2	ASTM A 775 epoxy	13	. 0
3	ASTM A 775 epoxy/aliphatic urethane	14/2	0/300
4	ASTM A 775 epoxy/acrylic latex	11/3	0/150

High VOC Control

Reg: BLSC + Basic Lead Silico Chromate, MH-P-24441 - U.S. Department of Defense Specification Wire-sprayed 85-15 + 85 percent zinc, 15 percent aluminum, TGIC - Triplytal isocyamurate 1 mil + 25 microns rack-mounted at a standard 45 degrees south exposure.

The OCRC exposure site is located approximately 100 yards (91 meters) from the Atlantic Ocean. The panels on the 2 bridges are attached to racks and exposed on locations under the bridge decks and on the exposed exterior facia beams. Both bridges span salt water, and the New Jersey bridge receives road salt in winter. The New Jersey bridge is approximately 15 ft (5 m) above the water, while the Louisiana bridge is approximately 100 ft (33 m) above the water.

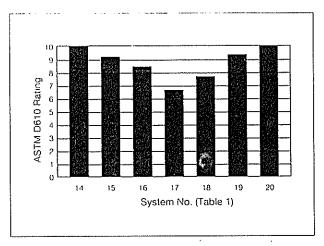
Panels are evaluated annually for rusting and scribe cutback using standard (ASTM) techniques. In addition, rusting is being evaluated using a novel digital image evaluation of each panel. The use of this technique is an attempt to develop a predictive method for evaluating coating systems under natural (i.e., non-accelerated) test conditions. Data generated by this technique are under analysis and will be reported at a later date. The standard ASTM data can easily be used to rank the various systems' performance over a test period of several years; however, the semiquantitative nature and inherent inaccuracies of the ASTM evaluation methods (e.g., D 610, Rusting) make the data generated virtually useless as predictive tools.

For the purposes of this article, ASTM ratings over three- to four-year periods will be presented.

 Task E. Coatings guide development: Using the data generated over the several years of natural exposure and associated material application, as well as maintenance costs for each system, a guide for cost-effective, environmentally acceptable bridge paint materials will be developed after the testing.

Present Status

The test program now includes 2 sets of natural marine environment exposure panels. One set is the natural marine exposure test panels exposed in conjunction with Task C laboratory testing. These panels represent all 34 Task C coating systems and have been exposed at the OCRC test site continuously for approximately 4 years. This set of panels consists of duplicate 6 in, x 12 in, (150 mm x 300 mm).



■ Fig. 3
Rust ratings of high VOC control systems at Sea Isle test site after 4 years' natural marine exposure (SP 10 surface preparation)

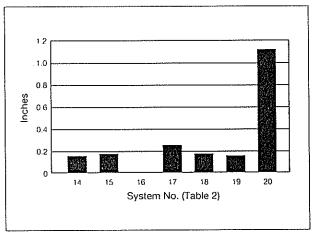


Fig. 4
Scribe cutback of high VOC control systems at Sea Isle test site after 4 years' natural marine exposure (SP 10 surface preparation); 1 inch = 25.4 millimeters

A-36 steel panels prepared in accordance with SSPC-SP 10 (Near White Blast) and SSPC-SP 2 (Pre-Rusted and Hand Tool-Cleaned) and left with adherent mill scale, and duplicate A-588 (weathering) steel panels prepared to SSPC-SP 10 and SSPC-SP 2 for each coating system for a total of 10 test panels per coating system. The Task C coating systems are listed in Table 1.

The second set of panels was exposed as Task D and consists of duplicate SSPC-SP 10, A-36 steel panels, duplicate SSPC-SP 2 A-36 panels, duplicate SSPC-SP 3 (Power Tool-Cleaned) A-36 panels, and SSPC-SP 10 A-588 panels for each of 13 coating systems. This replication results in a total of 8 panels per coating system. Replicate sets of these panels have been exposed in each of the 3 test loca-

Table 2 Task D Systems for Field Testing

System #	Generic Description	Dry Film Thickness (mils)	VOC Content (grams/liter)	
]	Inorganic zinc/epoxy/urethane	3.0/4.0/2.0	*	
2	Organic zinc/epoxy/urethane	3.0/4.0/2.0	*	
3	Inorganic zinc/epoxy/urethane	3.0/4.0/2.0	264/320/300	
4	Organic zinc/epoxy/urethane	3.0/4.0/2.0	240/192/300	
5	Inorganic zinc	4.0	0	
5	Epoxy mastic/urethane	7.0/2.0	264/276	
7	Epoxy mastic/urethane	7.0/2.0	122/257	
}	Epoxy mastic/acrylic/acrylic	6.0/1.5/1.5	250/250/250	
)	Three-coat acrylic latex	2.0/3.0/2.0	340/340/250	
10	ASTM A 775 epoxy/acrylic	8-10/3.0	0/250	
11	Flame-sprayed zinc	7.0	0	
2	Flame-sprayed zinc/aluminum (85-15)	7.0	0	
3	Flame-sprayed aluminum	7.0	0	

*High VOC Control 1 mil = 25 microns

tions for 3 years. Task D coating systems are listed in Table 2.

All exposure panels with either an SSPC-SP 2 or SSPC-SP 3 surface preparation were originally exposed bare at the OCRC for approximately 60 days prior to surface preparation and coating application. This period was sufficient to build a rust scale over the entire surface and to contaminate the surface with chlorides without causing appreciable pitting corrosion to the surface. Prior to cleaning, chloride contamination of the exposed panels was approximately $30~\mu g/cm^2$ on the panel surfaces.

Results to Date

Conventional Systems—4 Years' Exposure, SSPC-SP 106

Figure 1 shows the rust rating for all conventional low VOC systems originally exposed in Task C after 4 years at the OCRC test site.

Figure 2 shows the average scribe cutback for each system after 4 years of exposure.

After 4 years of natural marine exposure, the best performing conventionally ap-

plied coatings over an SSPC-SP 10 surface are as follows:

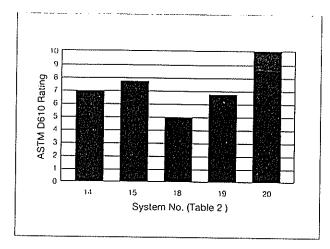
- System 1, water-borne alkali-silicate inorganic zinc;
- System 9, ethyl-silicate inorganic zinc/epoxy/urethane; and
- System 5, organic zinc-rich epoxy/epoxy/urethane.

These coatings all show virtually zero corrosion and no cutback at intentional scribes following 4 years of natural marine exposure over an SSPC-SP 10 surface.

The systems showing only slight rusting over the bold surfaces of the panels and showing K in. to K in. (3 mm to 13 mm) cutback from the scribe are as follows:

- System 4, epoxy mastic/urethane;
- System 7, epoxy mastic/water-borne epoxy-enamel;
- System 13, high solids phenolic/water-borne acrylic;
- System 8, water-borne styrene acrylic/water-borne acrylic; and
- System 10, water-borne acrylic (3 coats).

The systems showing either significant rust breakdown (≈ 8 or less) or more than ½ in. (13 mm) cutback over SSPC-SP 10 are as follows:



Rust ratings of high VOC control systems at Sea Isle test sites after 4 years' natural marine exposure (SP 2 surface preparation)

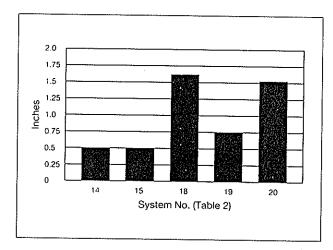


Fig. 8
Scribe cutback of high VOC control systems at Sea Isle test site after 4 years' natural marine exposure (SP 2 surface preparation); 1 inch = 25.4 millimeters

from the scribe but appeared to have significantly less edge breakdown than the remaining systems and showed little to no corrosion over the flat surfaces of the test panels after 4 years.

It is interesting to note that the waterborne acrylic (System 10) showed good corrosion and scribe cutback resistance for the first 3 years of exposure; however, during the fourth year of exposure, this system blistered and cutback severely at the scribe over SSPC-SP 2 surfaces.

The performance of the epoxy mastic coatings was disappointing. These coating systems are often considered "surface tolerant"; however, of the 4 low VOC systems of this type, only 2 had corrosion ratings of 9 or better and scribe cutback of less than

½ in. (13 mm) after 4 years in the marine environment.

Also evident in Figs. 5 and 6 is the lack of performance benefit provided by the app'ication of an organic zinc-rich epoxy primer under the epoxy/urethane coating system over a less than ideal surface.

Over SSPC-SP 10 surfaces, the zincrich primer that was applied appears to provide some undercutting resistance; however, this is not the case for SSPC-SP 2 surfaces.

Figs. 7 and 8 show similar data for the controls over SSPC-SP 2.

Metallized and Powder Coating Systems

After 4 years of natural marine exposure, the 13 metallized and powder coating systems can be divided into 2 basic groups—coating systems that provide protection and coating systems that do not.

Figures 9 and 10 show rusting and cutback data for these systems.

The following coatings do not perform well as marine corrosion control coatings based on 4 years of exposure data:

- System 10, flame-sprayed epoxy powder, and
- System 11, Triglytal isocyanurate-cured polyester powder.8

The remainder of the metallized and powder coatings systems have performed well in corrosion control to date. All panels of these coating systems are showing little to no breakdown with the following exceptions.

- Powder epoxy-coated panels with no topcoat show heavy chalking, typical of epoxies exposed to ultraviolet light.
- Powder epoxy-coated panels (topcoated/untopcoated) have cutback from the intentional scribe between ¼ in, to 1 in, (3 mm to 25 mm).
- The vinyl seal coat applied to the metallized systems tends to check and dishond. This phenomenon does not appear to affect corrosion control performance.
- There appears to be a performance difference between the wire-sprayed and powder-sprayed aluminum coatings. The wire-sprayed coatings are beginning to break down, whereas the powder sprayed are not. There is no evidence of rusting on any of the zinc or 85-15 zinc/aluminum panels.

- System 3, epoxy/urethane;
- System 6, aluminum epoxy/water-borne acrylic;
- System 2, water-borne inorganic zinc/acrylic;
- System 11, water-borne vinyl (2 coats); and
- System 12, water-borne acrylic (total failure).

It is interesting to note that of the 4 systems tested with (non-zinc) water-borne primers, none was among the outstanding performers; however, 2 were good performers, and 2 performed relatively poorly. This result is both encouraging and alarming. It is encouraging to see that water-borne technology has produced several coating systems that can compete on a performance level with some of the better solvent-borne barrier coating systems. It is alarming to consider the vast performance differences seen within the generic label of "water-borne," or even more specifically, "acrylic latex," coating systems (System 10 vs. System 12, for example).

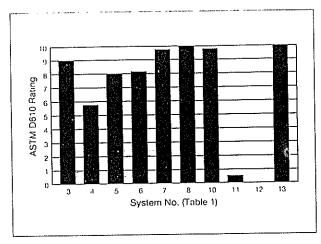
This performance difference can also be seen within the various solvent-borne generic types (e.g., epoxy mastics). The performance of the epoxy mastic primer systems was disappointing, especially in terms of scribe cutback resistance. Although most of the systems showed relatively good resistance to corrosion on the undamaged flat surfaces of the panels, only 2 of the 4 epoxy mastic systems (4, epoxy mastic/urethane and 7, epoxy/water-borne epoxy-enamel) performed well at the intentional scribe over SSPC-SP 10. Cutback of the epoxy mastic systems over SSPC-SP 2 was similar in magnitude to that over SSPC-SP 10.

These performance disparities make specification and selection of a coating system a difficult, and, necessarily, product-specific task.

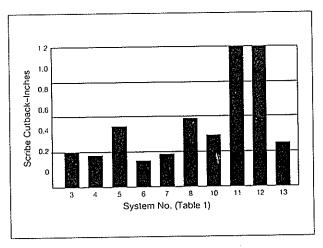
Figures 3 and 4 show rusting and scribe cutback data for the 7 high VOC control systems applied over SP 10. When these results are compared to Figs. 1 and 2, the relatively good performance of the low VOC systems is apparent. This result is encouraging considering the impending VOC regulations for AIM coatings.

Conventional Systems—4 Years' Exposure, SSPC-SP 2

As is evident from Fig. 5, after 4 years of natural marine exposure, all systems tested



■ Fig. 5 Rust ratings of systems at Sea Isle test site after 4 years' natural marine exposure (SP 2 surface preparation)



■ Fig. 6 Scribe cutback of samples at Sea Isle test site after 4 years' natural marine exposure (SP 2 surface preparation); 1 inch = 25.4 millimeters

over an SP 2 surface showed significant cutback (i.e., > ½ in.; 13 mm) from the intentional scribe.

In addition, some systems showed severe breakdown at the edges of the test panel (in spite of rather meticulous stripe coating of edges at paint application).

Several of the systems that were tested also failed totally due to corrosion over the flat surfaces of the test panels. Rusting data for the systems applied over SSPC-SP 2 surfaces appear in Fig. 6.

The performance of 2 systems was slightly better than the rest over an SSPC-SP 2 surface:

- System 3, epoxy/urethane, and
- System 7, epoxy/water-borne enamel.
 These systems still showed extensive cutback

Conventional Systems—3 Years' Natural Marine Exposure (Task D)

• SSPC-SP 10 Surface Preparation—Pigure 11 shows the rusting data for the three-year exposure panels in the 3 separate test locations.

Figure 11 shows the superior corrosion resistance of the coatings employing zinc primers (systems 1 through 5), as well as the metallized and powder systems (10 through 13). These systems show little to no corrosion over SSPC-SP 10 at all 3 sites. In addition, these systems show little to no cutback at intentional scribes with the exception of slight cutback for 1 of the organic zinc systems (System 4) at the OCRC test site. These data can be seen in Fig. 12.

The remaining conventionally applied coatings (6 through 9) all show at least some corrosion breakdown and, on average, increased cutback compared to the zinc systems after 3 years over SSPC-SP 10 surfaces.

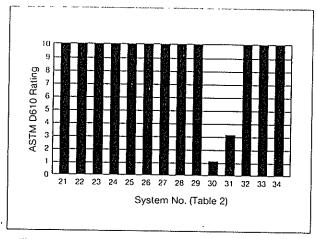
• SSPC-SP 2 Surface Preparation—As was the case with the four-year panels, all of the coating systems showed significant deterioration after 3 years over SP 2 surfaces. Figure 13 shows the performance of the systems tested over SP 2 at the 3 exposure sites. Figure 12 shows the corresponding scribe cutback data for the SP 2 panels exposed at the OCRC Natural Marine Exposure site.

Based on the data in Figs. 12 and 13, the overall best performing system over an SP 2 surface was organic zinc/epoxy/urethane (System 4); however, this system appears to provide only slight performance advantages over the epoxy mastic primer systems (6, 7, and 8). The organic zinc primer, although the best, did not perform well in corrosion control or cutback resistance over the 3 years of exposure.

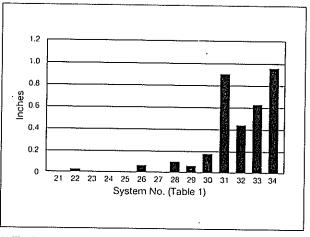
• SSPC-SP 3 Surface Preparation—Figure 14 shows the rusting data for the systems tested over SSPC-SP 3 surface preparations. Again, the scribe cutback data for these systems at the OCRC site can be seen in Fig. 12.

Figures 12 and 14 demonstrate several interesting results. The performance of systems 2 and 4 at all 3 sites indicates the extremely poor performance of the organic zinc primer systems over SSPC-SP 3. This result is somewhat surprising due to the apparent (slight) benefit of these primers over SSPC-SP 2 surfaces.

The most interesting result contained



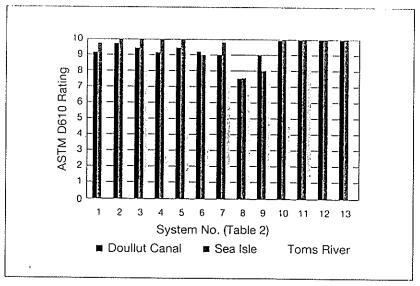
■ Fig. 9
Rust ratings of metallized/powder-coated systems at Sea Isle test site after 4 years' natural marine exposure (SP 10 surface preparation)



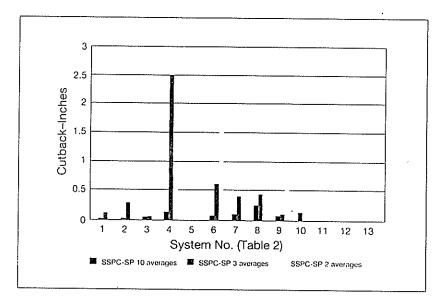
■ Fig. 10 Scribe cutback (inches) of metallized/powder-coated systems at Sea Isle test site after 4 years' natural marine exposure (SP 10 surface preparation); 1 inch = 25.4 millimeters

in Figs. 12 and 14 is the outstanding performance of systems 1 and 3 (solvent-borne inorganic zinc/epoxy/urethane). These systems are by far the best performers at all 3 sites over SSPC-SP 3 surfaces in both rusting and scribe cutback resistance.

In addition, the water-borne acrylic (System 9) appears to be performing competitively with the 3 epoxy mastic systems, outperforming these systems in scribe cutback, and equaling the median epoxy mastic system performance in rusting. These results are certainly contrary to the traditional marketing of these types of coatings. That is, inorganic zinc primers and (to a lesser extent) water-borne acrylic systems are generally not sold as "surface-tolerant" systems, whereas the epoxy mastics are



■ Fig. 11 Rust ratings after 3 years' exposure at 3 alternate sites (SP 10 surface preparation)



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■ Fig. 12 Scribe cutback (inches) after 3 years' exposure at Sea Isle, NJ; 1 inch = 25.4 millimeters

sold most specifically for non-ideal surface preparation applications.

Conclusions

· Based on 4 years of natural marine exposure testing, the performance of the low VOC systems using a zinc primer was significantly better than all of the low VOC barrier coating systems over SSPC-SP 10. One notable exception was System 2 (water-borne inorganic zinc/water-borne acrylic), in which the acrylic topcoat blistered and led to pinpoint rusting of the substrate.

The results of the natural marine exposures to date indicate that several commercially available low VOC (< 340 g/L [2.8 lbs/gal/l) bridge maintenance coatings meet or exceed the performance of the traditional high VOC (control) systems.

 The performance of the water-borne coating systems was inconsistent over SSPC-SP 10. Two of the 5 best performing barrier coating systems that were tested (i.e., non-zinc) were water-borne. These systems were the three-coat water-borne acrylic (System 10) and the water-borne styrene acrylic/water-borne acrylic (System 8, CAL-TRANS system).

However, one of the worst performing systems was a water-borne vinyl. This inconsistent performance indicates that coating selection must be formulation specific. Generic coating selection schemes may be highly misleading.

- None of the barrier systems performed well over an SSPC-SP 2 surface. Among the four-year systems, only 3 low VOC coating systems had an average rust rating of better than 8 (ASTM D 610) and scribe cutback of less than ½ in. (13 mm). These systems all exhibited scribe cutback of approximately ½ in. (13 mm). The performance of the best low VOC systems (epoxy mastics) was comparable to that of the control systems (lead alkyds) over SSPC-SP 2; however, the increased thickness of the low VOC systems should be noted. (See Table 1.)
- Among the systems exposed for 3 years over SSPC-SP 2, only the organic zinc/epoxy/urethane system had a rust rating as good as 8. This result was seen only at the Toms River Bridge. Based on these results, none of the coatings tested would be expected to offer long-term corrosion protection over a hand tool-cleaned surface in a marine environment
- · Contrary to the common requirement for application of inorganic zinc primers over a Near White (SSPC-SP 10) surface preparation. the solvent-borne ethyl silicate inorganic zinc/epoxy/urethane systems were the best performers after 3 years of exposure in 3 sepa-

rate sites over an SSPC-SP 3 (Power Tool-Cleaned) surface.

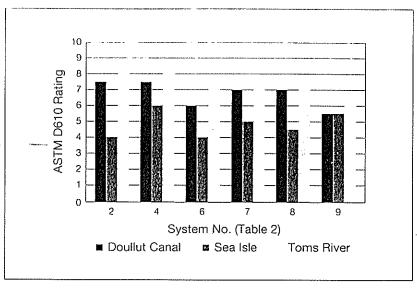
- All of the epoxy mastic systems are showing some degree (>¼ in. [6 mm]) of scribe cutback over SSPC-SP 10 surfaces after 4 years, and all of these systems are showing at least ½ in. (12 mm) of cutback over SSPC-SP 2 surfaces. This result does not support the claim that these materials perform well as surface-tolerant coatings in a marine environment.
- For all coatings tested over both SSPC-SP 2 and SSPC-SP 3 surfaces (three-year exposure results) except the low VOC organic zinc/epoxy/urethane system, the SSPC-SP 3 panels have performed better in terms of resistance to rusting. The low VOC organic zinc/epoxy/urethane system (System 4) cutback severely (i.e., total failure) over SSPC-SP 3 surfaces in less than 3 years. The cutback for this coating was much greater over SSPC-SP 3 than over SSPC-SP 2 surfaces.
- All of the metallized systems are performing well over SSPC-SP 10 with virtually no rusting or scribe cutback after 3 and 4 years of exposure.

Acknowledgments

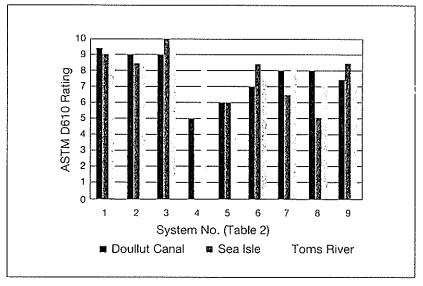
The authors would like to thank Kirt Clement, the Louisiana DOTD, Victor Matola, Tony Chmiel, and the New Jersey DOT for their assistance in this project.

Notes

- "Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges: Task C, Laboratory Evaluation," FHWA Report #FHWA-RD-91-060, Federal Highway Administration, Washington, DC, 1991.
- "Cyclic" tests consisted of exposure to the accelerated environment for 1 month followed by exposure to the natural marine environment for 1 month. This cycle was repeated 3 times for a total of 6 months of testing. Salt fog exposure was per ASTM B 117. Brine immersion consisted of immersion in a 150 F (66 C), 25 psig (172 kPa), 5 percent deicing salt solution.
- Coating systems with inorganic zinc, metallized, or powder coating primers were applied over SSPC-SP 10 surfaces only.
- Metallized and powder-coated panels were applied over SSPC/SP 10 surfaces only. Inorganic zinc primer systems were applied over SSPC/SP 10 and SSPC/SP 3 surfaces.



■ Fig. 13 Rust ratings after 3 years' exposure at 3 alternate sites (SP 2 surface preparation)



■ Fig. 14 Rust ratings after 3 years' exposure at 3 afternate sites (SP 3 surface preparation)

- 5. Approximately Rust Grade C, per SSPC-VIS 1-89.
- Data presented for SSPC-SP 10 surface preparation performances are averages of the data for A-36 steel and A-588 steel panels prepared to SSPC-SP 10. No significant differences in performance were seen between the 2 alloys.
- System 12, a two-coal acrylic latex, was obviously not designed for industrial use. This coating failed completely within 3 months of exterior exposure.
- TGIC-Polyester panels averaged 5 to 6 mils' (125 to 150 microns') thickness. Previous studies have shown improved performance of this coating at thicknesses near 10 mils (250 microns).

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Bob Kogler is the Engineering Manager of Ocean City Research Corp.'s Arlington, VA office, He is lead engineer on this FHWA study as well as on a study regarding bridge overcoating materials and strategies. Rogler has spent the past several years working on corrosion control projects involving protective coatings, cathodic protection. and materials selection issues for OCRC's clients. Kogler can be reached at Ocean City Research Corp., 1735 Jefferson Davis Highway, Suite 702, Arlington, VA 22202; 703/413-8266.

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Ventura County Air Pollution Control District Response to Southern California Paint Manufacturer's Association Regarding VCAPCD Rule 74.2

Background

The purpose of the proposed changes to Ventura County Air Pollution Control District Rule 74.2, Architectural Coatings, is to reduce emissions of Volatile Organic Compounds (VOC). These emission reductions are needed to meet state and federal air quality standards. The proposed changes are based on the California Air Resources Board Suggested Control Measure (SCM) or model rule for architectural coatings and will reduce approximately 1 ton per day of VOC emissions. Ventura County has been regulating these emissions since June 19, 1979.

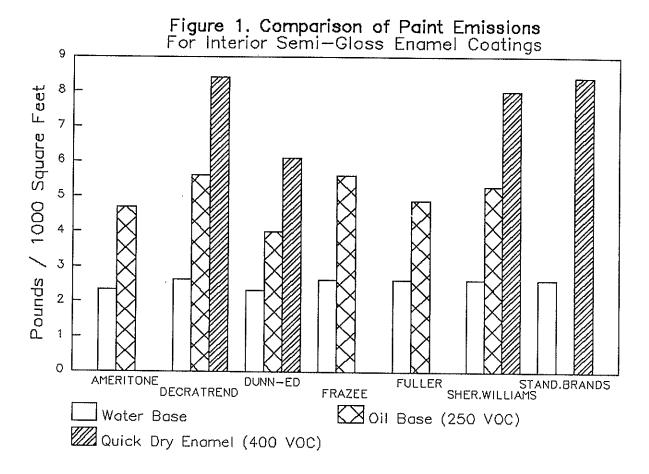
The process for developing the proposed changes began in 1988 when the SCM was first drafted. Three statewide public workshops and several meetings were held between paint manufacturers and the Technical Review Group's Architectural Coatings Committee. The Technical Review Group is an association of local, state and federal air pollution control agencies. Stan Cowen of the Ventura County staff is a member of this committee and actively participated in these discussions. The SCM was redrafted several times in response to comments received. The SCM was finally adopted by the Air Resources Board in May, 1989. Ventura County held a public workshop with industry on November 21, 1989. The Ventura County Air Pollution Control District Advisory Committee approved the SCM on February 27, 1990. This committee is appointed by the Air Pollution Control Board. After the workshop and at the Committee meeting, the proposed changes were revised based on comments received.

Introduction

The purpose of this paper is to respond to claims from the Southern California Paint Association that the proposed amendments to Rule 74.2 will increase rather than decrease VOC emissions to the atmosphere. This association has listed seven factors that they believe will cause increased VOC emissions. These factors are based on anecdotal rather than scientific analysis. No studies were cited by the paint association and no substantial evidence has been presented. The District has presented studies that show that there is no reasonable possibility that these amendments will increase VOC emissions.

Comparison of Emissions - High VOC vs. Low VOC paints

The indisputable fact is that a low VOC paint has lower emissions than a high VOC paint if the low VOC paint can perform satisfactorily. The difference in emission rates is easily seen in Figures 1, 2, and 3 for three different kinds of architectural paints: semi-gloss enamels; quick-dry stain blockers; and clear wood finishes. These graphs do not contain every architectural coating but are representative of these three coating categories. The high VOC coatings, represented by the solid bars, have higher emissions per square foot of surface painted than the low VOC oil base coating, represented by the striped bars, and are much higher than the water based coatings, represented by the clear bars. This data is derived from the information printed on the labels of each paint can or from manufacturer's data sheets.



The Southern California Paint Manufacturer's Association does not dispute the fact that low VOC coatings have lower emissions. They argue that the performance of the low VOC coatings creates problems that result in higher emissions. The Association has not presented any studies documenting this conclusion. The District believes that there are some problems with both high VOC and low VOC coatings, usually the low price coatings. However, the District has found low VOC coatings that it believes will work satisfactorily.

This conclusion is confirmed by the studies performed by the Consumers Union. One study is titled "Exterior Trim Paints" published in *Consumer Reports, September 1990*. The other study is titled "Interior Latex Paints" which will be published in *Consumer Reports, May 1991*. The Consumers Union tested 237 interior latex paints and 38 brands of trim paint (26 water based and 12 alkyd oil based) including 167 types and colors. Their study involved tests of following performance properties:

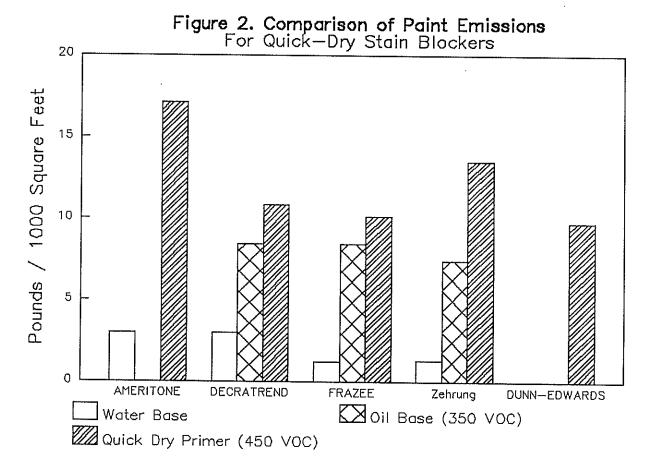
- 1. Brushing Ease
- 2. Leveling
- 3. Sagging
- 4. Adhesion
- 5. Blocking
- 6. Stain Removal
- 7. Scrubbing
- 8. Spatter

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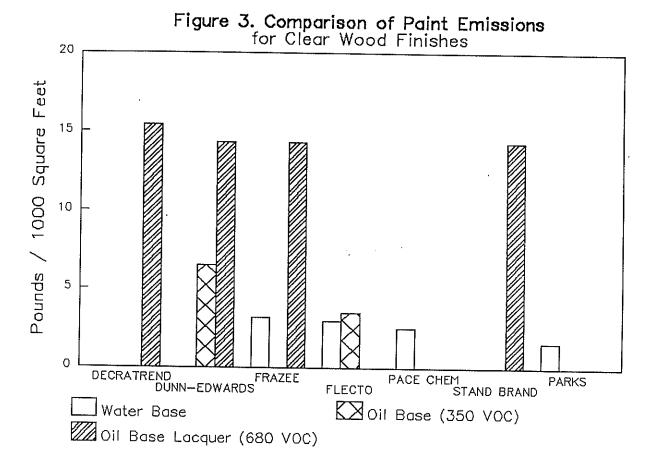
- 9. Blocking or Sticking
- 10. Water Resistance
- 11. Hiding Power

Although not all the low VOC latex coatings performed well, the Consumers Union recommended that consumers buy nine of these coatings based solely on coating performance. In addition, the Consumer Union agrees with the District about the air quality impacts of using high VOC alkyd paints vs. water-based latex paints. The following is a quotation from their second study:

"In addition, latex paints don't pollute the atmosphere as much as alkyds do. As they dry, alkyds release volatile organic compounds that can react with sunlight with other pollutants to produce ozone, a major component of smog." I



^{1. &}quot;Interior Latex Paints", Consumer Reports, to be published May 1991.



Response to Southern California Paint Manufacturer's Claims

This section is a discussion of the seven Southern California Paint Manufacturer Association's claims that use of low VOC coatings will be detrimental to air quality. These claims have not been substantiated by any study, while the District's analysis is supported by the two studies performed by the Consumers Union.

Claim Number One: Users apply more primers, sealers, and undercoaters, which are primarily solvent-borne to insure proper adhesion.

District Response: The Consumers Union devised a tough test to find out which paints adhere the best. They applied them to panels already coated with a paint designed to have a powdery, chalky surface. Such chalkiness provided a weak foundation for the next coat of paint and was not cleaned prior to coating. The Consumers Union aged the painted panels for several weeks. They then scratched them and pressed cellophane over the scratch. The amount of paint that pulled away with the tape was the measurement for adhesion.

Although this test showed that the alkyd paints had much better adhesion than the latex paints, the Consumers Union article stated that any of the latexes tested "should adhere to a chalky paint that has been scrubbed to remove the powder." The study also

 [&]quot;Exterior Trim Paints," Consumer Reports, Vol. 55, No.9, Sept. 1990, pages 619-623.

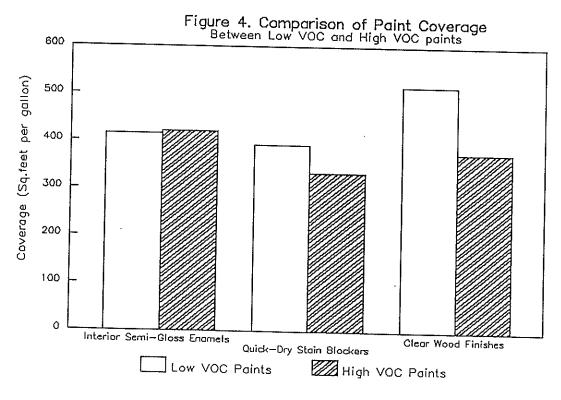
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indicated that two of the Benjamin Moore Latex coatings passed the adhesion test. Since this study was performed, several other manufacturers including Decratrend, Fuller O'Brien, Frazee, and others have developed new latex coatings that have improved adhesion properties, especially on to surfaces previously coated with an oilbase paint. The most critical factor for adhesion of any paint is proper surface preparation.

Claim Number 2. The new nonflat coatings produce a thicker film due to their higher viscosity. Thus, to cover a given area with one coat requires the use of more material.

District Response: Based on a survey of available paints, the coverage or amount of area covered per gallon of paint for low VOC paints is greater than or equal to the coverage for high VOC paints. This is graphed in Figure 4 for three different categories of coatings: interior semi-gloss enamels; quick-dry stain blockers; and clear wood finishes. The data are the averages of the coverage from all the coatings surveyed. This information was obtained from paint can labels or manufacturer data sheets.

The District survey showed that low VOC paints have better or equal coverage than high VOC paints. This conclusion is different from the one reached by the paint manufacturers because the paint industry did not consider a representative sample of the new nonflat coatings. They focused only on the oil based high solid nonflat coatings that may exhibit high viscosity and not on the low viscosity water based nonflat coatings. The District survey looks at both types of coatings, and the average coverage is graphed in Figure 4.



Claim Number 3. The new nonflat coatings are difficult to handle and apply. In response, many users add substantial amount of solvent thinners.

District Response: The claim focuses only on the new high solid, oil based nonflat coatings that may need additional thinner to apply. However, users are restricted from adding thinner that may cause a violation of the coating standards. These standards are on an "as applied" basis in the amendments to Rule 74.2.

Moreover, this claim misrepresents the types of coatings represented by the nonflat category. Most of the new nonflat coatings are water-based latex rather than oil based alkyds. The Consumer Union recently tested 237 cans of paint and all of them were interior latex paints. It is significant that they did not decide to test even one new alkyd nonflat coating.

No thinning of a latex coating is needed and cleanup is accomplished with soap and water. According to the Consumers Union:

"In ease of application, latex paints can't be beat. The alkyds we tested tended to make the brush drag and were apt to leave behind drips, runs and sags."

Claim No. 4 The new low VOC products do not hide or flow and level as well as the VOC rich products. Accordingly, users may have to apply more coats of low VOC products than they would have applied of VOC rich products.

District Response: The Consumers Union tested the hiding ability of both water based latex and oil based alkyd exterior trim paints. The test results show that the water based latex paints hide the surface as well as or better than the oil based paints. This means that compared to the oil based alkyd paints, the same number or fewer coats of water-based latex paints are required to cover the same type of surface. The results also showed that the color of the paint was the critical factor, and that the quality and quantity of the paint pigment were also important.

Claim No. 5 Many paint jobs attempted with the low VOC products fail immediately, and these jobs must be partially or completely redone. The solvent borne products have extremely long drying times and consequently they tend to bruise prior to drying, and they also yellow badly. The waterborne products stick or block. As to these problem jobs, the total amount of product used may be as much as doubled.

District Response: As shown by tests run by the Consumers Union, low VOC products do not fail and are recommended to their members as quality products. The solvent borne low VOC products represent a minority of the low VOC products since most are water-based latex. These water based products dry to touch within an hour or two and do not yellow like any low VOC or High VOC oil based coating. Recent tests of interior latex paints by the Consumers Union indicate equal or superior ability of the new latex paints to resist blocking or sticking compared to oil based paints.

Claim No. 6 Many of the low VOC coatings have impaired durability. Many such coatings also discolor very quickly, or exhibit excessive chalking.

 [&]quot;Exterior Trim Paints," Consumer Reports, Vol.55, No. 9, Sept 1991, page 619.

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District Response: The Consumers Union tested durability of exterior trim paints by weathering painted pine and hard board siding for nine months in the searing sun in Homestead, Florida and Mount Vernon, New York. The results of the outdoor tests showed that exterior latex paints resist color change, chalking, mildew, and dirt as well as or better than the oil based paints.

Interior latex paints were tested for their propensity to fade. The results of the indoor tests indicate that the latex paints resist fading extremely well for almost all colors. Enough high rated products exist so that the problem of fading for any color is minimal.

Claim No. 7 Solvent borne architectural coatings contain primarily mineral spirits that react somewhat slowly with NO_x to form ozone. Water borne architectural coatings contain glycol compounds that are substantially more reactive than mineral spirits. Because mineral spirits react more slowly than glycol compounds, the mineral spirit vapors are more likely to be dispersed in the upper atmosphere rather than be reacting at ground levels.

District Response: This claim has many flaws and is counter to the consensus of expert opinions in the air pollution control profession. Although glycol compounds may react more slowly than mineral spirits, this has never been demonstrated in photochemistry chamber studies. The key issue is not how fast an organic compound reacts but whether or not it is reactive. If a compound reacts more slowly, then the formation of ozone simply occurs further downwind. An air pollution episode can last several days under stagnant conditions with an inversion layer that traps pollutants. Under these conditions, there is very little opportunity for dispersion of the pollutants, reactive or not.

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